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GREAT II Upper Mississippi River  
Work Group Appendix

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# Water Quality Work Group Appendix

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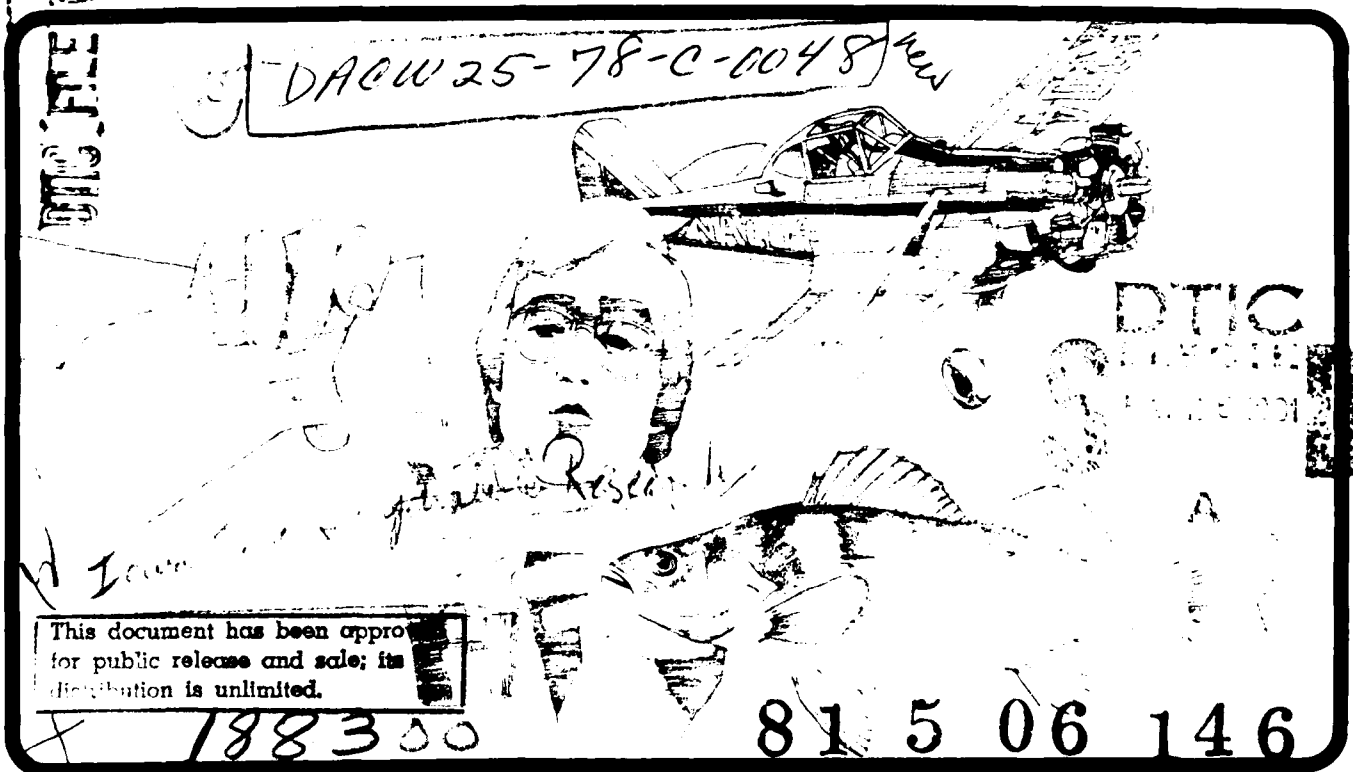
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# GREAT II

Upper Mississippi River  
(Guttenberg, Iowa to Saverton, Missouri)

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## Great River Environmental Action Team

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## Executive Summary

The Water Quality Work Group, GREAT II, consisted of members representing the Rock Island District, Corps of Engineers, the U.S. Fish and Wildlife Service, U.S. Environmental Protection Agency (Regions V and VII), Wisconsin Department of Natural Resources, Iowa Division of Environmental Quality and the Missouri Department of Natural Resources. This group was responsible for identifying water quality problems on the Mississippi River, formulating appropriate studies to better define or solve the most important of these problems, and finally to make recommendations to the Plan Formulation Work Group supportive of water quality interests.

Thirty-five problems were identified by the work group and the public. Seventeen of the identified problems were addressed (due to the broad nature of some problem statements, many of these problems were only partially addressed) by work group activities. Four other problems were too low on the priority list for funding of studies. The remaining fourteen problems were considered more appropriate to other work groups within GREAT II, to studies being conducted by GREAT I, or were beyond the scope of the GREAT process.

The major accomplishments of the work group were: studies on water quality effects of dredge disposal site return flows, and on desorption of pollutants from sediments. These studies were contracted to the University of Iowa, Institute of Hydraulic Studies. The final reports of these contracts not only explain study results but develop predictive water quality models to be used by the Rock Island District Corps of Engineers in estimating impacts of dredging, a requirement of the 404 permit process. Results are summarized below.

**Modeling of Suspended Sediment Plumes:** Return flows at the Rock Island and Keithsburg sampling sites showed increases in suspended sediments of up to 75 mg/l over ambient levels in the river. There was no

discernible return flow at Hannibal. Sand-sized material settled within the first 100 meters and silt sized particles, generally within 400 to 500 meters.

The Schubel-Carter model and the Weschler-Cogley model were evaluated for accuracy and ease of use. The Schubel-Carter model, originally developed for estuaries, was modified to work on conditions more typical of the Upper Mississippi. This model proved to be awkward in its solution and was not recommended for consideration. The Weschler-Cogley model has more promise and can utilize "plane" as well as "point" sources of suspended material. A "plane" source is a more accurate description of side bank or beach nourishment disposal than a "point" source. A third model is being developed by Sayre. The final report will contain 27 solutions for the Weschler-Cogley model representing a variety of conditions, and a user manual.

**Laboratory Desorption of Pollutants:** Three sediment samples each from 10 sites were analyzed as was river water and elutriates. At some sites there was considerable variation in the size and character of the pollutants. As expected, sandy sediments were generally very low in pollutants and finer-sized sediments somewhat higher. In general, ammonia, COD, manganese and sometimes oil and grease, cadmium and zinc were desorbed from sediments. Iron, phosphate, and copper seemed to adsorb to sediments during elutriate tests.

Water quality standard violations in elutriates occurred infrequently. The secondary drinking water standard for manganese was occasionally exceeded.

A report on the water quality of the Upper Mississippi River and a point-source discharge inventory of the river were generated internally by the Work Group. A summary of water quality problems is presented in table i.

Table i

EXTENT OF WATER QUALITY STANDARDS VIOLATION  
IN THE UPPER MISSISSIPPI RIVER

LENGTH OF AFFECTED SEGMENT (MILES)	STANDARD VIOLATION			
	DRINKING WATER	PROTECTION OF AQUATIC LIFE	FISH FLESH	WHOLE BODY CONTACT RECREATION
Entire Length	Iron (1)* Manganese(1)	Mercury (1)		
100-500		Dieldrin (4) Sediment (4) Copper (2)		Fecal Coliform from St. Louis Area (3)
10-100	Lead (2)	Other Pesticides (4)	PCBs (2) Dieldrin (4)	Fecal Coliform from Quad Cities (3)
1-10	Mercury (2)	Dissolved Oxygen (2,3)		
0-1		Heat (2)		

\*Major Sources:

1. Natural Weathering and Erosion
2. Industrial and Commercial Wastes
3. Domestic Waste
4. Agricultural Non-point

The Water Quality Work Group recommended the following measures to the Plan Formulation Work Group:

U.S.E.P.A. should revise suspended and settleable solids standards so that they are based upon the need to protect fisheries and aquatic habitat rather than to protect the photosynthetic process.

(RID/COE use the quantitative assessment models of water quality impacts of dredging developed by the WQWG);

States in the GREAT II study area should institute industrial pre-treatment programs as soon as possible, concentrating on specified towns, and should press for better treatment or resource recovery for specified industries;

States in the GREAT II study area should develop compatible water quality manage-

ment regulations and strategies for the river;

All NPDES thermal monitoring reports should be standardized and should utilize existing mathematical modeling of the heat dispersion process and;

A group of monitoring stations should be established by USEPA in the Mississippi River below the Quad Cities to document the degree of water quality degradation and rate of recovery from this pollution source.

From the water quality perspective, it was recommended that all dredge disposal occur out of the floodplain and that waters in the dredge spoils be retained at the disposal site until they are of equal quality to the water in the river. On-site inspection by officials of the Savanna Proving Grounds would precede any disposal on the SPG.

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## 1. INTRODUCTION

The Mississippi is the greatest river in North America, gathering run-off from 31 states and two Canadian provinces and draining 1.5 million square miles. It is the third largest watershed in the world, flowing 2,500 miles to the Gulf of Mexico. Millions of people live on its banks and draw life from its waters. Over five hundred kinds of animals live along it, and the plant communities that thrive in and along the river.

Man, in his progress, has put the river to many varied and sometimes conflicting uses. The pressures of use are tending to be degrading the environmental qualities of the river. More information is needed on the complex interactions of the river's resources and these resource reactions to man's activities. When this information is obtained, it can be used to determine what problems exist and what alternatives are available to solve the problems and coordinate river uses to minimize conflicts.

### A. Study Authorization and Development

In response to increasing public concern for the environmental quality of the river, the Great River Study was authorized by Congress in the Water Resources Development Act of 1976 (PL 94-587). This legislation authorizes the U.S. Army Corps of Engineers "... to investigate and study, in cooperation with interested states and federal agencies, through the Upper Mississippi River Basin Commission, the development of a river system management plan..."

The total study program includes three Great River Environmental Action Teams (GREAT), which have the responsibility for the river reaches from St. Paul/Minneapolis to Guttenberg, Iowa (GREAT I); Guttenberg to Saverton, Missouri (GREAT II); and Saverton to the confluence of the Ohio (GREAT III).

The study programs and recommendations of the three GREAT Teams will be brought together into a river management strategy for the entire Upper Mississippi

river. The goal of the study is to present to Congress and the people a river resource management plan that is, above all, realistic - a plan that is technically and economically sound, socially and environmentally acceptable, and capable of being put into action within a reasonable period of time.

### B. Study Purpose and Scope

The purpose of the GREAT II Studies is to identify and resolve conflicts resulting from separate legislative actions of Congress which mandated that the Upper Mississippi River be managed in the national interest for commercial navigation and as a fish and wildlife refuge.

The concept of the study originated from a need to coordinate the maintenance activities of a nine foot navigation channel by the U.S. Corps of Engineers from Guttenberg, Iowa to Saverton, Missouri with other river uses. GREAT II was founded because of increasing concern by conservationists and the general public over the lack of information available about the impacts of U.S. Corps of Engineers channel maintenance activities on many key resources of the river.

The scope of the GREAT II Study is directed toward developing a river system management plan incorporating total river resource requirements. GREAT II was organized early in fiscal year 1977 (October 1976 through September 1977) and is studying the river from Guttenberg, Iowa to Saverton, Missouri.

### C. Study Participation and Organization

The GREAT II Team is composed of representatives from the following Upper Mississippi Basin States and the U.S. River Resource Administration:

State of Illinois  
State of Iowa  
State of Missouri  
State of Wisconsin

U.S. Department of the Interior -  
Fish and Wildlife Service

U.S. Department of Agriculture -  
Soil Conservation Service

U.S. Department of Defense -  
Department of the Army -Corps of  
Engineers

U.S. Department of Transportation -  
U.S. Coast Guard

U.S. Environmental Protection  
Agency

Upper Mississippi River Conserva-  
tion Committee (ex officio)

GREAT II is organized into 12 func-  
tional work groups and the Plan For-  
mulation Work Group. Each work group  
is to accomplish the study objectives as  
they relate to the work group's func-  
tional area and as directed by the team.  
Work groups are composed of persons  
having expertise and interest in the  
work group's area of study.

This report summarizes the con-  
cerns, objectives, activities, conclusions  
and recommendations of the Water  
Quality work group as they relate to the  
GREAT II Study area.

#### D. Water Quality Work Group Organi- zation

1. Participants. Those members of the  
work group who have attended at  
least 2 of the 5 meetings include:

Ruth Andrews-R.I.C.O.E.  
Thomas Bainbridge-Wise. DNR.  
Rick Breitenbach-U.S.F.W.S.  
Bryan Goodrum-R.I.C.O.E.  
Rich Greenwood-U.S.F.W.S.  
George Johnson-R.I.C.O.E.  
Robert Koke-U.S.E.P.A., Region  
VII  
  
William Koellner-R.I.C.O.E.  
V. Ramiah-Missouri DNR  
David Stoltzenberg-U.S.E.P.A.,  
Region V

Others who have participated in the  
review and comment of work group  
output include:

Steve Baumgart-IOWA DEQ  
David Kennedy-Wise. DNR  
Thomas Lovejoy-Wise. DNR

#### Work Group Chairman:

Robert Koke - U.S.E.P.A. until  
January 1978

V. Ramiah - MO DNR January  
1978 - October 1978

John Ford - MO DNR October  
1978 - Present

#### 2. Meetings and Procedures

As of October 1, 1979 the Water  
Quality Work Group had held six  
meetings. The first three meetings  
occurred between November, 1977,  
and March, 1978. During these  
meetings, work of the GREAT I  
study was reviewed, water quality  
problems in the GREAT II area  
identified and studies proposed. The  
fourth and fifth meetings of the  
work group were held in June and  
September, 1978, to finalize details  
of the studies to be undertaken or  
contracted out by the work group.  
The sixth meeting was held in  
September, 1979 to discuss the re-  
sults of work group-sponsored  
studies and work group recommen-  
dations to the final report.

No formalized rules of order were  
observed.

#### 3. Voting Procedures

Since the work group represented a  
single interest, water quality on the  
Mississippi River, it was agreed that  
all motions should pass by consensus  
of all work group members present.  
When quick decisions were needed,  
members were contacted by tele-  
phone and consensus of all re-  
sponding members was required.

#### 4. Division of Responsibilities

The following items were the re-  
sponsibility of all work group mem-  
bers:

- review of existing data pertinent to the work group, problem identification, design of studies, review and comment on GREAT II Water Quality Work Group studies, formulation of conclusions and study recommendations.

Responsibilities of the chairman include:

- drafting study contracts, reviewing contractor proposals,

recommendation of a contractor, reviewing interim contractor progress reports, scheduling and presiding at work group meetings, represent work group on Plan Formulation Work Group, On-Site Inspection Team, and Post-Disposal Task Force, writing water quality assessment report, develop point source discharge map, write water quality work group appendix of the final study report.

## II. PROBLEM IDENTIFICATION

### A. Problem Identification Process

Once the twelve functional work groups and their overall objectives were formulated, the work group members began to identify public concerns, conflicts and other problems related to their overall objective and area of study. A work group's list of problems was composed of those problems identified in any of the following ways:

1. The problem was identified in GREAT I and was applicable to the GREAT II area.
2. The particular work group recognized an existing problem based on existing conditions.
3. The particular work group recognized a potential problem based on future projections of existing conditions and trends.
4. Other work groups identified concerns relating to the particular work group area of study.
5. The public expressed concerns and problems directly to the particular work group.
6. The public expressed concerns and problems to a particular work group through the public participation and information work group (i.e. town meetings; houseboat trips; etc.).

These problems were compiled into a list to be evaluated by the particular work group for: (1) their relevancy to the study, (2) the urgency or certainty of the problem and, (3) the potential for resolving the problem within the time-frame of the study. Certain problems were eliminated from further study based on criteria guidelines developed by the Upper Mississippi River Basin Commission in 1974. The list of remaining problems was then prioritized by the work groups. (See Plan Formulation Work Group Appendix for the listing of these problems.)

The results of this screening process were put into tables and displayed in the Preliminary Feasibility Report.

Once the work groups had developed a set of problems and needs, they formulated a list of objectives designed to address and, at a minimum, partially resolve their problems. These objectives were then used to identify tasks and/or studies which the work group needed to accomplish in order to identify the possible alternative solutions to their respective problems. The problems, objectives and tasks, therefore, represent the plans-of-actions each work group used to derive their final conclusions and recommendations.

The conditions, both existing and future, which were used to identify problems of a work group are discussed in the following sections. The year 1979 was chosen as a base point for existing conditions, and a project life of fifty years was used to predict future conditions. Attachments 1, 2, and 3 summarize the plan-of-action for each work group.

### B. 1979 Conditions

1. Present Water Quality Conditions.  
See Section VII A. Water Quality Assessment Report.
2. Sources of Pollutants to Mississippi River in GREAT II Study Area.

The most important sources of pollution to the Mississippi River in the study area are point source municipal and industrial discharges from large cities directly to the river and the delivery of sediments from erosion of agricultural land. The urban areas of Dubuque, Clinton, and Quad Cities, Muscatine, Burlington, Fort Madison and Keokuk are the major dischargers of point source pollutants to the Mississippi. The

Rock, Iowa, Manquoketa, Skunk, Des Moines and Fabius Rivers are the major sources of sediment discharged to the Mississippi.

### 3. Relationship of Riparian Land Management and Water Quality.

The uses made of land adjacent to the Mississippi River present these potential non-point source problems for water quality in the river:

- increased soil erosion rates of riparian land,
- discharge of pollutants used, generated or stored on riparian land.

The potential for adverse impacts on water quality increases as the amount of land contributing to the problem increases and as the distance from the river decreases. The spectrum of riparian land uses would run from a bottomland hardwood forest, which would provide the best water quality protection, to an industrial site with large areas of unvegetated soil or impervious paving and polluting substances exposed to surface runoff or subsurface leaching to the river.

### 4. Relationship of River Use and Water Quality.

Many uses are made of the river, but water quality is affected in one of two general ways. The use can entail discharge of pollutants into the river or it can affect the status of pollutants already in the water. Those uses contributing discharges to the river would be:

- recreation and operation of recreational and commercial river craft (oil and grease, sanitary wastes, spills of transported materials),
- withdrawal of waters for industrial and municipal uses (a wide range of pollutants).

Those uses which can affect the location or status of pollutants already in the river include dredging and the operation of commercial rivercraft (turbidity, resuspension of bottom sediments, desorption of pollutants from bottom sediments).

### 5. The Relationship of Present Use and Water Quality.

All the above uses never all affect water quality but not all have the same degree of impact on water quality. The withdrawal of water for domestic, commercial and industrial use, and its return to the river carrying waste products of this use, has, by far, the greatest effect on water quality in the river. Indicators of organic pollution (nutrients, fecal coliforms) from large urban areas can extend many miles downstream from their source (Sec. VII A) in the Mississippi, but studies by GREAT I Water Quality Work Group (1978) showed increased pollutant concentration caused by resuspension of sediments during dredging disposal persisted no further than 1 mile downstream.

Studies conducted by Johnson (1976) and the GREAT I Water Quality Work Group (1978) summarize known impacts of rivercraft on water quality. These studies on the Mississippi, Minnesota and Illinois Rivers demonstrated increased turbidity levels correlated with size of craft and depth of channel. Turbidity remained above ambient levels for as much as 2½ hours, but the consequences of this kind of pollution is still less severe than that of discharges from large urban areas.

### 6. Relationship of the Study Area's Economy to Water Quality.

Changes in water quality would be expected to mediate changes in:

- public health (viral and bacterial infections, and cancer, and

therefore health care costs and per capita productivity of the areas work force are affected).

water treatment costs (municipal drinking water, industrial boiler and process water) vary with water quality.

- development of public recreation areas along the river (water quality standards which agencies may require certain water quality standards be met before a stream can be designated for a particular use such as recreation. Failure to maintain these standards would tend to reduce the state's commitment to providing recreation along that stream).
- value of migratory waterfowl. Much of the study area, particularly Pool 19, has been the major feeding ground on the Mississippi flyway due to the large numbers of Musculium transversum, a clam which appears to be quite sensitive to water quality. (Thompson and Sparks 1977, Anderson et al. 1977).
- value of sport and commercial fishery (the survival of a high quality diverse fishery is dependent upon maintaining high levels of dissolved oxygen and low levels of pollutants).

## 7. Relationship of Dredging and Water Quality.

Dredging has the following impacts on river water quality:

- increased levels of suspended solids. The action of the dredge cutterhead and return flows from the disposal sites can increase suspended solids levels in the river. Studies by the GREAT I Water Quality Work Group (1978) showed dredging induced turbidity subsided to background levels within a mile below the dredge site. Studies of turbidity generated by

return flows, mounted of three separate dredgings in the GREAT II segment of the river and found plumes of elevated suspended solids extended as far as one quarter mile downstream from the return flow discharge. Measurement of heavy metals, nutrients and fecal coliform concentrations indicate they are strongly correlated with suspended sediments. The concentration of pollutants seem to return to background levels at about the same rate as do suspended sediments.

- increased levels of pollutants caused by desorption from dredged sediments. Many studies have shown the potential for, or the occurrence of desorption of metals and nutrients from dredge spoils. Studies by Brannon (Brannon, no date) showed that manganese was released from sediment interstitial water from mineral particle surfaces and from particles associated with oxides and hydroxides of hydrous manganese. Zinc was found to be released from particles associated with oxides and hydroxides of hydrous iron and manganese and from organic matter and sulfides.

A summary of the 1978 dredging program water sampling by the Rock Island District Corps of Engineers showed COD, iron, manganese and zinc desorbed from sediments. Measurements during actual dredging showed that depending upon the site, manganese and COD appeared to be either adsorbed to or desorbed from sediments. Laboratory studies conducted by GREAT II Water Quality Work Group indicate that COD, ammonia and manganese are desorbed from sediments.

## 8. Public Concerns.

A number of water quality issues were raised by participants at public meetings including:

- a need to better understand how water quality affects the biota of the Keokuk Pool (Pool 19).

- the relationship of water quality and recreational boating.
- point source discharges in Ft. Madison, Iowa.
- farm chemicals and sediment.
- coordination of the GREAT Study with state water quality regulatory agencies.
- water pollution control costs.
- point source discharges from 3M plant.
- relationship of barge tows and propeller size on bottom turbulence and turbidity.
- thermal pollution by power plant cooling water.

C. Projected Conditions 2025

1. Projected State and Federal Actions.

Without the GREAT Study, there may not have been a consensus among bordering states and EPA regions as to what constitutes adequate water quality assessment of dredging and disposal impacts, and what level of impact we can live with on the Upper Mississippi. Such a lack of consensus among agencies would make compliance with state and federal regulations concerning dredging more difficult. Without the GREAT Study a mathematical expression of water quality impacts caused by dredging may not have been developed to assist in water quality management decisions.

2. Projected Water Quality Disturbance Sources.

Increased population in the study area should be reflected in an increase in all major water uses. Municipal and industrial point sources should increase in number and in total pollutant load dis-

charged to the river. More intensive use of riparian land (commercial or industrial development, more barge fleeting areas, or cultivation to near river edges) will result in greater non-point source pollution in the Mississippi.

3. Projected Water Quality.

An increase in water quality is projected above can be expected to decrease water quality. There are, however, some trends that may help mitigate or offset this regression in water quality:

- continued local, state and federal government funding for collection systems, construction of new sewage treatment facilities and upgrading of existing plants.

increased emphasis on industrial pretreatment and recovery of materials as byproducts rather than their discharge as wastes.

- use of organic wastes from large sources (i.e., grain processing) as alternative energy sources for the production of methane or alcohol, as a livestock feed or fertilizer.

development of urban non point pollution abatement plans.

4. Public Concerns.

Future public concerns will, of course, mirror public perception of water quality. The public view of two segments of the river today may indicate how concerns will change through time with changing water quality. In Wisconsin, Mississippi water quality is considered good and the major concerns are with providing aesthetically pleasing recreational boating and maintaining a high-quality sport fishery. Water quality in the Mississippi below St. Louis, in contrast, is considered poor and public meetings suggest the

major concerns are at a much more fundamental level — human health and the maintenance of aquatic life in the river (GREAT III Public Participation Work Group).

- D. Statements of Problems. (Attachment #1).

- E. Statement of Objectives. (Attachment #2).

- F. Formulation of Work Group Tasks. (Attachment #3).

Attachment #1

PROBLEM IDENTIFICATION

WORK GROUP -- Water Quality

1. STATEMENT OF PROBLEM (LIST IN CHRONOLOGICAL ORDER)	2. DATE IDENTIFIED	3. AGENCY, GROUP, ETC. WHO IDENTIFIED	4A. IS THE PRO- BLEM BEING ADDRESSED BY GREAT II?	4B. IF IT IS, BY WHICH TASKS	4C. IF IT'S NOT, WHY NOT?
1) There is a lack of coordinated water quality and sediment quality data in the study area on which to base management decisions.	12/19/78	GREAT I	Yes	1, 2	--
2) There is a lack of data on surface and groundwater quality as affected by dredging and disposal on which to base management decisions.	12/19/78	GREAT I	Partially	3, 4	Will not address groundwater quality.
3) There is a lack of data on the effect of navigation on water quality, on which to base management decisions.	12/19/78	GREAT I	No	--	Will use information developed in GREAT I.
4) Operation and maintenance of the 9-foot channel may contribute to the PCB problem.	12/19/78	GREAT I	Yes	3, 4	
5) It is not known whether legislative and institutional arrangements are adequate to successfully manage water quality.	12/19/78	GREAT I	Partially	5	Recommendation but no study.
6) Shipment of hazardous materials may endanger water quality.	12/19/78	GREAT I	No - see problem #19	--	--
7) Collection and treatment of wastewater in the Twin Cities has an adverse impact on water quality in the study area.	12/19/78	GREAT I	No	--	Inappropriate to scope of GREAT II.

WORK GROUP - Water Quality	PROBLEM IDENTIFICATION	Attachment #1
STATEMENT OF PROBLEM LIST IN ADDITION TO ORIGIN	DATE IDENTIFIED	
3. AGENCY, GROUP, ETC. WHO IDENTIFIED BY GREAT II	4A. IS THE PRO- BLEM BEING ADDRESSED BY GREAT II	4B. IF IT IS, BY WHICH TASKS WHY NOT?
Water plant replacement activities have a severe impact on water quality	GREAT I No	Not within scope of GREAT II.
Presence of dual sources of water quality is unknown and hinders proper management of water quality	GREAT I Yes	1, 2
There is eutrophication in the study area which results in large amounts of aquatic plant growth and a loss of lake water effects	GREAT I Partially	Will analyze nutrient levels to determine trophic status in relation to what it should be.
Some of the water is seepage from the water treatment plant require monitoring of frequency and water quality	GREAT I No	Beyond the scope of GREAT.
Partial of the water treatment plant is seeping materials is seeping	Water Quality Work Group Yes	3, 4, 5
There is a problem with the grade water quality	Water Quality Work Group No	Is being addressed by GREAT I. Will use results.
There is a problem with the water quality in the of Upper Mississippi River area	Water Quality Work Group Yes	1

WORK GROUP -- Water Quality		PROBLEM IDENTIFICATION				Attachment #1
1. STATEMENT OF PROBLEM (LIST IN CHRONOLOGICAL ORDER)	2. DATE IDENTIFIED	3. AGENCY, GROUP, ETC. WHO IDENTIFIED	4A. IS THE PROBLEM BEING ADDRESSED BY GREAT II?	4B. IF IT IS, BY WHICH TASKS	4C. IF IT'S NOT, WHY NOT?	
15) Upland erosion is contributing sediment to the river.	1/30/78	W.Q.W.G.	Yes	Sediment & Erosion Control Work Group	--	
16) Stream bank erosion is contributing sediment to the river.	1/30/78	W.Q.W.G.	Yes	Sediment & Erosion Control Work Group	--	
17) Urban runoff is contributing sediment, oil and grease, organics, and other pollutants to the river.	1/30/78	W.Q.W.G.	No	--	Beyond Scope of GREAT	
18) Point source discharges contribute many pollutants to the river.	1/30/78	W.Q.W.G.	Yes	See problem #9	--	
19) Accidental spills, including shipment of hazardous materials and pipeline and railroad spills, degrade water quality in the river.	1/30/78	W.Q.W.G.	No	--	Limited time and funding -- too low on priority list.	
20) Clam shell dredging creates high levels of turbidity.	3/22/78	W.Q.W.G.	No	--	Limited clam shell dredging in GREAT II area.	
21) There is insufficient understanding of how water quality affects the biota of the Keokuk Pool.	3/22/78	Public	No	--	Limited funding and time -- too low on priority list.	

WORK GROUP -- Water Quality		PROBLEM IDENTIFICATION				Attachment #:
1. STATEMENT OF PROBLEM (LIST IN CHRONOLOGICAL ORDER)	2. DATE IDENTIFIED	3. AGENCY, GROUP, ETC. WHO IDENTIFIED	4. IS THE PROBLEM BEING PLANNED BY WHO?	4B. IF YES, BY WHICH TASKS	4C. IF IT'S NOT, WHY NOT?	
22) Recreational boating.	3/22/78	Public	No	--	Too low on priority list to receive funding.	
23) A concise bibliography does not exist which compiles research on the effects of navigation and channel maintenance on water quality.	2/22/78	W.Q.W.G.	No	--	Too low on priority list to receive funding.	
24) There are philosophical differences as to how the river should be used.	3/78	F.W.W.G. Chairman	No	--	Beyond scope of GREAT II WOWG	
25) Point source discharges in Ft. Madison are degrading water quality.	8/78	Public	Partially	1	Too site specific for a special study.	
26) Farm chemicals & sedimentation are degrading water quality.	8/78	Public	Partially	1	Will only address pollutants in main stem of Mississippi.	
27) There may not be adequate coordination with the Iowa DEQ. They are starting to crack down on polluters along the river.	8/78	Public	Yes	5, 7, 8, 9		
28) Costs of cleaning up effluent, etc., are high.	8/78	Public	No	--	Beyond the scope of GREAT.	

WORK GROUP - Water Quality

PROBLEM IDENTIFICATION

Attachment #1

1. STATEMENT OF PROBLEM (LIST IN CHRONOLOGICAL ORDER)	2. DATE IDENTIFIED	3. AGENCY, GROUP, ETC. WHO IDENTIFIED	4A. IS THE PRO- BLEM BEING ADDRESSED BY GREAT II?	4B. IF IT IS, BY WHICH TASKS	4C. IF IT'S NOT, WHY NOT?
29) Effluent from 3M Plant may be degrading water quality and should be checked.	8/78	Public	Partially	1	Summary of effluent analysis will be included.
30) Subsidized barge traffic encourages all out grain production which increases erosion, which causes more dredging. What effect does the size of barge tows have upon bottom turbulence and general turbidity, and do the bigger propellers hasten water quality deterioration?	8/78	Public	No	--	See problem 13 - will use same information.
31) What can GREAT do to speed up EPA on approving our secondary sewage treatment plant plans and get it under construction?	8/78	Public	No	--	Beyond scope of GREAT.
32) Thermal pollution caused by discharge from nuclear plants may degrade water quality.	12/78	N.C.D. of C.O.E.	Yes	1	--
33) There is inadequate knowledge of flow regimes to predict movement of pollution.	5/79	Public	Yes	3, 4	
34) Municipal water plants do not keep detailed enough records to evaluate significant water quality changes over the years.	5/79	Public	No	--	Most cannot afford the sophisticated equipment & high operational costs of accurate water analysis. Long term water quality monitoring is the responsibility of State & Federal (USGS) agencies.

WORK GROUP - Water Quality

PROBLEM IDENTIFICATION

Attachment #1

1. STATEMENT OF PROBLEM (LIST IN CHRONOLOGICAL ORDER)	2. DATE IDENTIFIED	3. AGENCY, GROUP, ETC. WHO IDENTIFIED	4A. IS THE PRO- BLEM BEING ADDRESSED BY GREAT II?	4B. IF IT IS, BY WHICH TASKS	4C. IF IT'S NOT, WHY NOT?
35) The effects of large rainfalls within the basin on river water quality is not well known.	5/79	Public	No	--	The massive commitment of time & money is well beyond the scope of GREAT.

## STATEMENT OF OBJECTIVES

WORK GROUP Water Quality

### OVERALL OBJECTIVE:

Promote the maintenance or improvement of water quality in the GREAT II study area.

### SUB-OBJECTIVES:

1. To characterize present water quality in the study area, including spatial and temporal water quality trends, and locations and frequencies of water quality violations.
2. Assess the effectiveness of present water quality monitoring programs in the study area.
3. Develop modeling procedures that will predict the water quality impacts of dredging and dredge disposal on a site specific basis.
4. Promote the formation of a uniform set of guidelines for all agencies involved in water quality management in the study area.
5. Provide for mitigation of the adverse water quality effects of dredging and disposal, during the period prior to development of final water quality criteria for dredging and disposal.

WORK GROUP -- Water Quality

FORMULATION OF TASKS

Attachment #1

DESCRIPTION OF TASK	PURPOSE OF TASK	PERSON(S) OR GROUP RESPONSIBLE FOR COMPLETION OF TASK	PROBLEMS ADDRESSED BY TASK	ANTICIPATED COMPLETION DATE OF TASK
1. Write an assessment report of present water quality in the study area.	Define present water quality of the Mississippi in the study area.	Chairman, Water Quality Work Group	1, 9, 16, 24, 25, 26, 29, 32	October 1, 1976
2. Identify and map location of all direct point source discharges to the Mississippi in the study area.	To aid in the interpretation of water quality data. To aid in the formulation of management recommendations.	Chairman, Water Quality Work Group	1, 9	October 1, 1976
3. Assessment of Dredge-Disposal Related Water Quality Problems.	Adjust two existing mathematical models of particle dispersion to typical conditions encountered in the Mississippi River.	Institute of Hydraulic Studies, Univ. of Iowa, Dr. Gerald Schaefer	2, 4, 12	October 1, 1976
4. Lab Simulation of Desorption of Pollutants	Develop a mathematical model describing desorption of potentially toxic materials from dredge material.	Institute of Hydraulic Studies, Univ. of Iowa, Dr. Gerald Schaefer	2, 4, 12	December 1, 1976
5. Develop recommendations for final report consistent with water quality objectives.	Promote objectives of the work group.	Water Quality Work Group	5, 27	
6. Assist in writing water quality appendix for final report.	To assist in completion of report document.	Chairman, Water Quality Work Group		
7. On-Site Inspection.	Make recommendations on disposal sites to be used.	Water Quality Work Group	27	

8. Post-Disposal Task Force.	Evaluate impact of disposal on the chosen site after dredging is complete. Summarize water quality impacts.	Chairman, Water Quality Work Group	27	
9. Attend Water Quality Work Group Meetings.	Formulate and execute activities of water quality work group.	Water Quality Work Group	27	

### III WORK GROUP ACTIVITIES/ACCOMPLISHMENT

#### A. Water Quality Assessment Report.

The purpose of the report was to provide an overview of current water quality on the Upper Mississippi River. Although many reports on specific pollutants in specific areas and many sources of raw data exist, a compilation and analysis of all data for the river was needed to help put specific pollutants and locations in the proper perspective so that sound water quality management decisions could be made.

The report provided information on pollution caused by organic enrichment and contamination by heavy metals and chlorinated hydrocarbons on a 600-mile segment of the Upper Mississippi River.

The report draws ambient water quality data primarily from the Illinois DEQ and the U.S. Geological Survey. Information on point sources came primarily from state 303e basin planning documents and state records on effluent monitoring. Special studies by a wide variety of states and agencies provided much of the information on mercury, other heavy metals, PCBs and pesticides.

Writing the report was a task of the work group chairman. Total chairmanship costs from February 1, 1978 to September 30, 1979, are estimated at approximately \$28,000; costs incurred in the writing of the water quality report are estimated at \$5,000. Printing and distribution may add another \$6,000-7,000 to the cost of the report.

Results and conclusions of the report are summarized in the report abstract.

#### B. Point Source Discharge Map.

A map of the GREAT II study area showing known point source discharges to the Mississippi was made with the aid of the state's 303e basin plan documents

and communication with state officials. The map has aided in the interpretation of water quality data. It should be useful in future planning and management in the fields of recreation, floodplain management and protection of fish and wildlife, as well as water quality.

Development of map information was included in the water quality report costs. Additional costs of obtaining base map, drafting and printing are estimated at \$2,000.

#### C. Dredge Disposal Assessment.

A study to determine turbidity and suspended sediment problems below dredge disposal return flows was contracted to the University of Iowa, Institute of Hydraulic Studies. The three major components of the study were:

1. Monitor turbidity below dredge disposal sites and define plume of turbid water.
2. Establish the relationship between turbidity and suspended solids at the sites monitored.
3. Adjust two existing mathematical models of suspended solids dispersion to fit field data obtained at disposal sites.

The cost of the study is \$30,000.

A detailed explanation of methods, results and conclusions are included in the final report issued for this study printed under separate cover.

#### D. Laboratory Simulation of Desorption of Pollutants from Dredged Sediments.

A study to determine which potential pollutants may be released from sediments into the water column during dredging and dredge disposal was contracted to the University of Iowa.

Institute of Hydraulic Studies. The three major components of the study were:

1. Determine which pollutants will desorb from Upper Mississippi River dredge material using elutriate testing.
2. Determine the rates at which desorption takes place.
3. Develop a mathematical model of dilution which will translate source concentrations to concentrations in a downstream plume.

The cost of the study is \$77,100.

A detailed explanation of methods, results and conclusions are included in the final report issued for this study printed under separate cover.

E. On-Site Inspection.

The Water Quality Work Group did not develop criteria which would reject potential disposal sites. The major water quality concern of a specific disposal site was its distance upstream from whole body water contact recreation areas and water supply intakes. These concerns could be addressed without field inspections. Therefore, participation of the On-Site Inspection Team was infrequent.

F. Post-Disposal Evaluation.

The work group chairman will participate in the 1979 post-disposal task

force and, as a part of that work, will summarize and discuss the water quality data gathered by the Rock Island District Corps of Engineers for the 1979 dredging season.

G. Work Group Meetings and Discussions.

Minutes of the Water Quality Work Group meetings are included as Section VII B.

H. Management Tool Development.

The completion of the two studies contracted to the University of Iowa should lead to formulation of mathematical methods to predict water quality impacts of dredging and dredge disposal. The limited time and data base for construction of these predictive techniques strongly suggests that additional refinement of these techniques will be needed. By expanding the data base and by verification through water quality monitoring during dredging, the accuracy of the predictive techniques will be improved. It is anticipated that further model refinement and verification will be an activity of the GREAT III Water Quality Work Group.

It is hoped that this work will lead to a method of quantitatively assessing the water quality impacts of dredging acceptable to all agencies involved in water quality management.

## II. FORMULATION OF ALTERNATIVES AND RECOMMENDATIONS

### A. Process

The tasks that each work group chose to accomplish varied by work group, by type of problem and by the existing knowledge about that problem. All work groups needed to collect and organize background information. This background information was used to identify future problems, to provide input and data for other work groups and to form part of the narrative for their work group appendix. Where little background information existed, baseline data was collected and/or research studies conducted.

As all tasks were completed, the results were distributed to members of the pertinent work group. Conclusions were then drawn by members of the work group based on the results of their work group's tasks.

The conclusions developed by each work group led to the identification and consequent development of potential alternatives to their problems. The results of some tasks indicated that there still was not enough available information to ensure a knowledgeable assessment of the potential alternative solutions to a problem. In these cases, no alternatives could be formulated and the only recommendation which could be made was for further study of the problem. Where completion of work group tasks led to identification of potential solutions, the alternatives were displayed on Attachment 4. The alternatives varied in specificity from site-specific guidelines to general policy changes, dependent upon the problem they were addressing. Alternatives displayed on Attachment 4 were assessed and an alternative selected on the basis of a judgmental impact assessment. Once an alternative was selected, the rationale for its selection and all available supporting documents, information and studies supporting its selection were identified and displayed on Attachment 4. This information (and other), was used to compile a brief summary of the types of impacts that would result if the recommendation were imple-

mented.\* Based on the impact assessment and careful evaluation of the recommendation, the work group through various voting procedures, either approved or rejected the recommendation.

All work group approved recommendations were sent to the GREAT II impact assessment coordinator for review and advice. The coordinator would then mail this information, complete with comments, back to the appropriate work group chairman. The work group then did a more thorough and detailed assessment of the impact potential of their recommendations. This information was recorded on Attachment 7. Each work group was responsible for obtaining or estimating the necessary information for their impact assessment through their studies, work group meetings, discussions with other work groups, discussions with other agencies having expertise in that particular field, discussions with economists and discussions with the impact assessment coordinator. When Attachment 7 was completed to the work groups' satisfaction, sufficient copies of Attachment 4 and 7 were brought to the next Plan Formulation Work Group meeting. The impact assessment was reviewed by all members present, and additions, changes or suggestions were made to the impact assessment. Each work group chairman made the appropriate revisions and brought a final version of the impact assessment to the next Plan Formulation Work Group meeting for final review.

At this time, the recommendations were dropped from further active consideration, until all recommendations were submitted by all of the work groups. When all of the recommendations had been submitted to the Plan Formulation Work Group, the development of integrated and final plans began.

\*Table II, page

The recommendations brought to the Plan Formulation Work Group varied in specificity and implementability and were grouped into the following general categories:

1. Implementable actions with existing authority.
2. Implementable actions requiring legislation.
3. Implementable studies within existing authority.
4. Implementable studies requiring legislation.
5. Feasibility studies, etc.
6. Policy changes.

Within each of the six groups above, the recommendations varied from general rec-

ommendations applying to the river as a whole to those recommendations site specific in nature. Three categories of specificity used to organize the recommendations into action plans are listed below:

1. general - apply to entire GREAT II reach or entire Upper Mississippi River Basin.
2. pool - apply to a specific pool or group of pools.
3. site - apply to a specific site(s) within a pool.

#### B. Work Group Recommendations

The following recommendations represent those of the Water Quality Work Group before they were modified by the Plan Formulation Work Group in the plan development process.

### RECOMMENDATION #1

U.S. EPA in conjunction with interested states should develop new *water quality criteria for suspended and deposited sediments.*

As a result of the sedimentation studies conducted by the United States Environmental Protection Agency, the following pertinent information was obtained in a recent sedimentation study. Sedimentation may exist to be a greater threat to desirable aquatic habitat than diminished primary productivity on the Gulf of Mexico. Water quality management would be better served by criteria which protect habitat as well as the phytoplanktonic process.

June 26, 1979

Attachment #4  
WQ Work Group

DISPLAY OF RECOMMENDATION 5  
PRELIMINARY IMPACT ASSESSMENT

Recommendation Number 1

Pool Number VII

River Mile 10.0 - 10.5

Date Approved by Work Group 6/26/79

1. General problem addressed (write out & use number from Attachment #1):
  - #2. There is a lack of data pertaining to surface & groundwater quality & how it is affected by dredging & dredge disposal.
  - #1. There is a lack of coordinated water quality & sediment data in the study area on which to base management decisions.
  - #4. Operation & maintenance of the 9-ft. channel may contribute to the Pool problems.
  - #12. Pollution due to dredging practices & disposal of materials is occurring.
  - #20. Clam shell dredging creates high levels of turbidity.
2. Sub-problem addressed (write out - use only when necessary):
3. Sub-objective addressed (taken from Attachment #2 - write out):

Promote the formation of a uniform set of guidelines for all agencies involved in water quality management in the study area.
4. Tasks accomplished to address problem (taken from Attachment #3 - write out):

Develop recommendations for final report consistent with work group objectives.
5. Listing of alternatives to problem:
  - a. Further research on water quality & aquatic habitat impacts of suspended sediment & sedimentation rates should be conducted & water quality criteria developed based on this research.

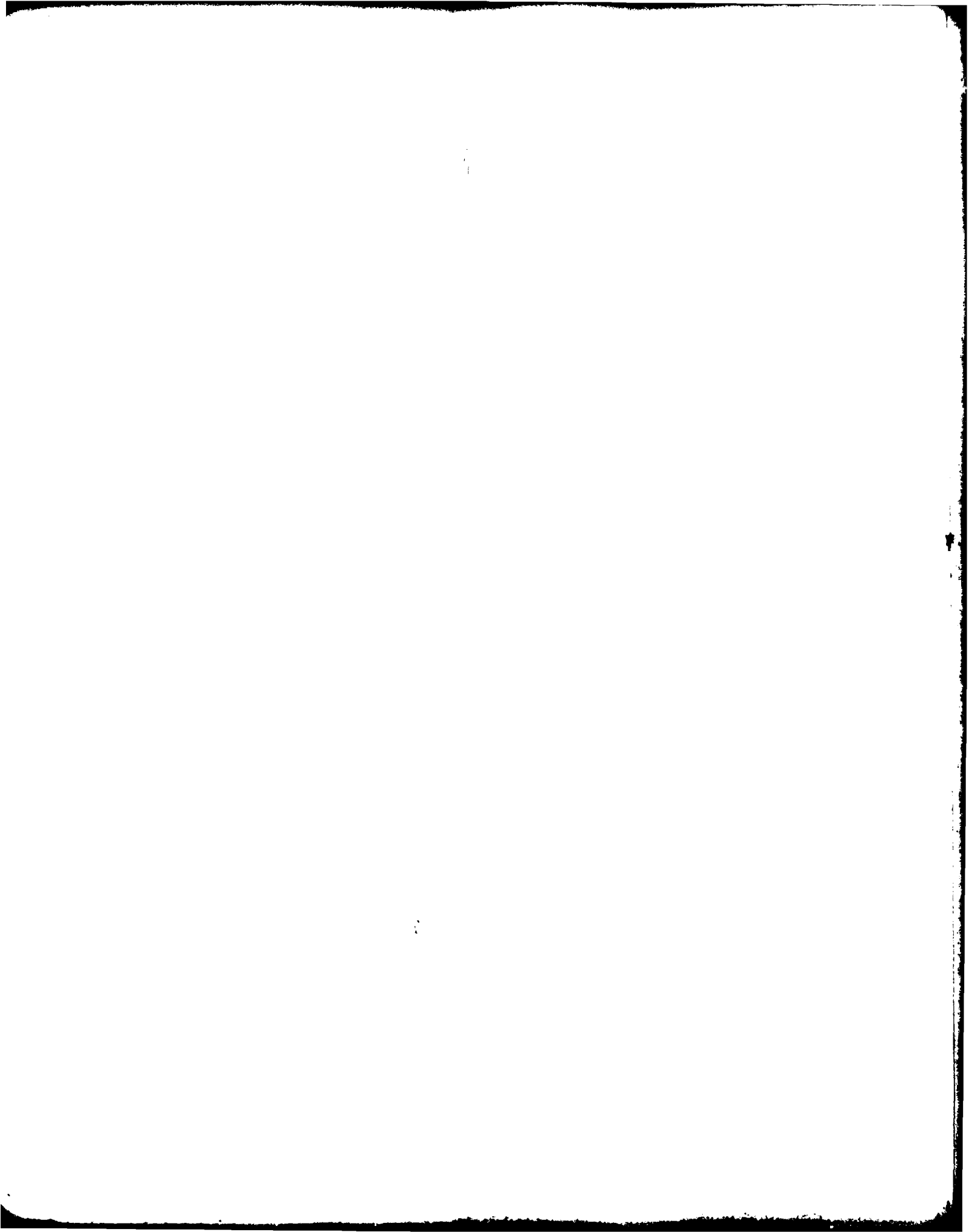
- c. Water quality criteria should not be developed for suspended sediment.
6. Selected alternative: \_\_\_\_\_ (write in the letter).
- a. Rationale for selection of alternative: The present uncertainty over the impacts of dredging on water quality in the Mississippi has hindered interagency cooperation and agreement. A criterion for evaluating water quality impacts of dredging is needed to determine the actual severity of dredging impacts. The following factors are given in water quality criteria for the river. Current technology are *not* *from* benthic systems in the reservoirs come directly from the Upper Mississippi River. Most agencies would not accept criteria based on assumptions from existing data.
- b. Rationale for rejection of alternative: One study, support document and a description of the study, attached.
- c. Alternative rejected primarily through discussion with representatives of the ILL COE, W.F.S., and the states of Wisconsin, Iowa, Illinois, and Missouri. Reports including those of the DMRP of W.F.S., U.S. F.W.S. Tech. Paper No. 94.
7. Rationale for elimination of other alternative: See above.
- a. Existing research findings are not appropriate to the Upper Mississippi River.
- b. Federal and state laws require that water quality impacts be assessed by all 404 applicants, therefore, criteria to judge impacts are needed.
10. Preliminary impact assessment of selected alternative: (List below all general impacts which can be identified by the work group. The level of detail required is only that for which the information is readily available.)
1. Increased research costs.
  2. Improve water quality management skills.
11. Reason for work group rejection of recommendation:



# RECOMMENDATION EPA ASSESSMENT FORM

3. DESCRIPTION OF MOST PROBABLE FUTURE WITH RECOMMENDATIONS (COA 5-001.4)	4. DESCRIPTION OF MOST PROBABLE FUTURE WITHOUT RECOMMENDATIONS	5. DESCRIPTION OF MOST PROBABLE FUTURE WITH RECOMMENDATIONS	6. MEASUREMENT OF IMPACTS (COA 5-001.4)
<p>Greater protection of the wetland values of these backwaters &amp; side channels.</p>	<p>Value of the property as wetlands &amp; water base recreation would be enhanced or enhanced.</p>	<p>Value of the property as wetlands &amp; water base recreation would be enhanced or enhanced.</p>	<p>Enhanced value of land as a wetland &amp; water base recreation area. Reduced value as potential for land.</p>
<p>Enhanced value of land as a wetland &amp; water base recreation area. Reduced value as potential for land.</p>	<p>Value of the property as wetlands &amp; water base recreation would be enhanced or enhanced.</p>	<p>Value of the property as wetlands &amp; water base recreation would be enhanced or enhanced.</p>	<p>Enhanced value of land as a wetland &amp; water base recreation area. Reduced value as potential for land.</p>
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State, only appropriate toxicity tests.



RECOMMENDATION # 2

RID/COE should supplement their assessment techniques using mathematical models developed during the GREAT II study for documenting water quality impacts of dredging and disposal.

Compliance with specific water quality criteria requires quantitative measurement of impacts. Impact assessment of COE dredging and disposal on water quality should use mathematical models to predict the magnitude of suspended sediment and desorbed pollutant plumes. Such models will be a product of the GREAT II Water Quality Work Group and these models, along with user manuals, will be presented to RID/COE. Further refinement and verification of these models is planned in the GREAT III study.

It is further recommended that RID/COE put these models into use at two locations each during the 1980 and 1981 dredging seasons. RID/COE should design their water quality monitoring schemes during dredging to check the accuracy of the model predictions.

June 26, 1979

Attachment #4

W.Q. Work Group

DISPLAY OF RECOMMENDATION &  
PRELIMINARY IMPACT ASSESSMENT

Recommendation Number 2  
 Pool Number All  
 River Mile \_\_\_\_\_  
 Date Approved by Work Group \_\_\_\_\_

1. General problem addressed (write out & use number from Attachment #1):

- #2. There is a lack of data pertaining to surface and groundwater quality as it is affected by dredging and disposal.
- #4. Operation and maintenance of the 9-ft. channel may contribute to the PCB problem.
- #12. Pollution due to dredging practices and disposal of dredge materials is occurring.
- #20. Clam shell dredging creates high levels of turbidity.

2. Sub-problem addressed (write out - use only when necessary):

3. Sub objective addressed (taken from Attachment #2 - write out):

Develop modeling procedures that will predict the water quality impacts of dredging and dredge disposal on a site specific basis.

4. Tasks accomplished to address problem (taken from Attachment #3 - write out):

Assessment of dredge disposal related water quality problems.  
 Lab simulation of desorption of pollutants.

5. Listing of alternatives to problem:

- a. The COE should improve their w.q. assessment capabilities using mathematical modeling based upon research findings made before GRLAF study.

- b. The COE should improve their w.q. assessment capabilities using mathematical modeling based upon data collection and existing model modifications undertaken by the GREAT study.
- c. The COE should improve their w.q. assessment capabilities without the use of mathematical models.
- d. The COE does not need to improve its w.q. assessment capabilities.
6. Select an alternative: B (write in the letter).
7. Rationale for selection of alternative: Since a mathematical model based on conditions typical to the study area is used, the assessment can be quantitative (which is necessary if impacts are to be compared with established criteria) and more accurate than a more generalized model.
8. References used to select alternative (use tasks, support documents and/or discussions, studies, articles, etc.):
- Discussions among members of water quality work group, discussions and correspondence with WES staff and WES documents of the DMRP.
9. Rationale for elimination of other alternatives:
- a. Mathematical models are presently not sufficiently developed to accurately predict w.q. impacts in the study area.
- c. A non-mathematical assessment procedure cannot quantify impacts and, therefore, cannot compare them with established criteria.
- d. Present COE w.q. assessment is viewed as inadequate by several agencies involved in w.q. management in the study area.
10. Preliminary impact assessment of selected alternative. (List below all general impacts which can be identified by the work group. The level of detail required is only that for which the information is readily available.)
1. Increase research and model development costs.
  2. Improve water quality through improved water quality management skills.
11. Reason for work group rejection of recommendation:

## IMPACT

## ASSESSMENT FORM

LOCATION (RIVER MILE)

POOL All

1. LIST OF IMPACTS (SEE ATT. #4)	2. UNITS TO BE MEASURED IN	3. PRESENT CON- DITION AS OF JAN. 1, 1979 FOR EACH IMPACT	4. DESCRIPTION OF MOST PROB- ABLE FUTURE (2025) WITHOUT RECOMMENDATIONS	5. DESCRIPTION OF MOST PROBABLE FUTURE (2025) WITH RECOM- MENDATIONS	6. MEASURE OF IMPACTS (COL. 5-COL. 4)
1. Increased model development and verification costs.		DMRP has conducted several studies on dredge spoil dispersion and on desorption of toxics but not under conditions similar to the Upper Mississippi River.	DMRP has con- cluded some work on particle disper- sion in rivers. Continues at cer- tain universities generally with fed- eral funds.	GREAT II expendi- tures are \$77,000, those of RD/COE for 1980-81 are estimated at \$44,000.	Development and operation costs through 1981 are estimated at \$121,000.
2. Improve water quality manage- ment skills.	Correctness of manage- ment deci- sions.	There is uncertainty and concern over the w.q. impacts of dredging in the Upper Mississippi River	Some improvement due to continued sampling.	Greater improvement due to incorporation of all sampling data into a fac- tor of w.q. impacts usable as a w.q. manage- ment tool.	Mngt. decisions can be made based on quantitative rather than more generalized quali- tative information.

RECOMMENDATION # 3

All dredge material disposal sites should be located out of the floodplain.

June 26, 1979

Attachment #4  
W.Q. Work GroupDISPLAY OF RECOMMENDATION &  
PRELIMINARY IMPACT ASSESSMENT

Recommendation Number 3  
 Pool Number All  
 River Mile \_\_\_\_\_  
 Date Approved by Work Group \_\_\_\_\_

1. General problem addressed (write out & use number from Attachment #1):
  - #4. Operation and maintenance of the 9-ft. channel may contribute to the PCB problem.
  - #12. Pollution due to dredging practices and disposal of dredge materials is occurring.
2. Sub-problem addressed (write out - use only when necessary):
3. Sub-objective addressed (taken from Attachment #2 - write out):
 

Provide for mitigation of the adverse water quality effects of dredging and disposal during the period prior to development of final w.q. criteria for dredging and disposal.
4. Tasks accomplished to address problem (taken from Attachment #3 - write out):
 

Participation in OSIT, post-disposal task force.
5. Listing of alternatives to problem:
  - a. Stabilize spoils at a location out of the floodplain.
  - b. Stabilize spoils of materials within floodplain but not adjacent to the river.
  - c. Allow disposal at any site conditional upon stabilization of material at site.
  - d. Place no strictures on disposal of dredge spoils.

6. Selected alternative   a   (write in the letter).
7. Rationale for selection of alternative: Generally, this alternative would provide the greatest protection from erosion of spoils back into the river.
8. References used to select alternative (use tasks, support documents and/or discussions, studies, articles, etc.):

Participation in on-site inspection team and post-disposal task force, discussion with RID/COE personnel and participation in formation of channel maintenance plan.
9. Rationale for elimination of other alternatives: All other alternatives provide less protection from erosion of spoils back into river.
10. Preliminary impact assessment of selected alternative. (List below all general impacts which can be identified by the work group. The level of detail required is only that for which the information is readily available.)
  1. Increased cost of dredge disposal at many locations.
  2. Increased beneficial use of dredge material.
  3. Reduction in sediment load to the river.
11. Reason for work group rejection of recommendation:

## RECOMMENDATION

3

LOCATION (RIVER MILE)

IMPACT

POOL

All

## ASSESSMENT FORM

1. LIST OF IMPACTS (SEE ATT #4)	2. UNITS TO BE MEASURED IN	3. PRESENT CON- DITION AS OF JAN. 1, 1979 FOR EACH IMPACT	4. DESCRIPTION OF MOST PROB- ABLE FUTURE (2025) WITHOUT RECOMMENDATIONS	5. DESCRIPTION OF MOST PROBABLE FUTURE (2025) WITH RECOM- MENDATIONS	6. MEASURE OF IMPACTS (COL. 5-COL. 4)
1. Increased cost of dredge dis- posal.	\$	Most disposal sites are in the floodplain ad- jacent to the river. Disposal costs are minimized.	Same as present.	Disposal costs would increase.	
2. Increased value dredge material.	\$	Most dredge material placed adjacent to river is accessible and useable only by rec- reationists as a beach.	Same as present.	More dredge material will be accessible for other uses and will in- crease in value.	
3. Reduced sediment load to river.	Suspended sediment con- centration and bedload.	Much of the dredge material placed adjacent to river erodes back into the river at high river stages.	Same as present.	There will be little erosion of dredge mate- rials back into the river.	
4. Marine re- sources re- duced	Acres	Some presently used disposal sites create or sustain sand beaches at the edge of the river.	Same as present.	No further beach disposal would occur.	Reduction in size and number of sand beaches at river edge in the GREAT II study area.
5. Floodplain habitat loss	Acres Quality of habitat	Loss of habitat in the flood- plain	Same as present.	No further loss of floodplain habitat due to dredge disposal, increased loss of upland habitat due to dredge disposal.	Scarcer floodplain habitat is pre- served at the expense of more common upland habitat.

RECOMMENDATION # 4

All dredge disposal material, including water, must be contained at the disposal site. Release of water back to the river should not occur until the quality of the contained waters equals that of the river. Impacts of return flows on lands and receiving water courses shall be minimized.

June 26, 1979

Attachment #4  
W.Q. Work Group

DISPLAY OF RECOMMENDATION &  
PRELIMINARY IMPACT ASSESSMENT

Recommendation Number 4  
Pool Number All  
River Mile \_\_\_\_\_  
Date Approved by Work Group \_\_\_\_\_

1. General problem addressed (write out & use number from Attachment #1):
  - #4. Operation and maintenance of the 9-ft. channel may contribute to the PCB problem.
  - #10. There is eutrophication in the study area which results in large amounts of aquatic plant growth and shoaling of backwaters.
  - #12. Pollution due to dredging practices and disposal of dredged materials is occurring.
2. Sub-problem addressed (write out - use only when necessary):
3. Sub-objective addressed (taken from Attachment #2 - write out):

Provide for mitigation of the adverse water quality effects of dredging and disposal during the period prior to development of final w.q. criteria for dredging and disposal.
4. Tasks accomplished to address problem (taken from Attachment #3 - write out):
5. Listing of alternatives to problem:
  - a. Require complete containment of water on site until return flows are at least of equal quality with water in the river.
  - b. Require containment of waters on a site specific basis.
  - c. Do not require containment of waters at any site.
6. Selected alternative a (write in the letter).

7. *Rationale for selection of alternative:* This alternative provides the most protection against w.q. problems caused by dredge spoils return flows. Groundwater pollution will not occur since the pollutants held in the containment areas are sediments which will not penetrate the soil, and very small concentrations of metal cations which will be bound by soil particles.
8. *References used to select alternative (use tasks, support documents and or discussions, studies, articles, etc.):*

Participation in OSIT, post disposal task force, discussion with RID COL and personnel from state w.q. management agencies.

9. *Rationale for elimination of other alternatives:*

These alternatives provide less protection from water quality problems caused by dredge spoil return flows.

10. *Preliminary impact assessment of selected alternative. (List below all general impacts which can be identified by the work group. The level of detail required is only that for which the information is readily available.)*

1. Increased cost of disposal.
2. More land needed to contain water.
3. Improved water quality.

11. *Reason for work group rejection of recommendation:*

RECOMMENDATION # 4  
 LOCATION (RIVER MILE) \_\_\_\_\_  
 POOL \_\_\_\_\_  
 RECOMMENDATION  
 IMPACT  
 ASSESSMENT FORM

1. LIST OF IMPACTS (SEE ATT. #4)	2. UNITS TO BE MEASURED IN	3. PRESENT CON- DITION AS OF JAN. 1, 1979 FOR EACH IMPACT	4. DESCRIPTION OF MOST PROB- ABLE FUTURE (2025) WITHOUT RECOMMENDATIONS	5. DESCRIPTION OF MOST PROBABLE FUTURE (2025) WITH RECOM- MENDATIONS	6. MEASURE OF IMPACTS (COSTS, BENEFITS, ETC.)
1. Increased cost of disposal.	\$	Containment of re- turn waters is used at some dredge dis- posal sites where ad- verse effects (i.e. erosion) is anticipated from re- turn flows. Some dis- posal costs are due to return flow contain- ment.	Same as present.	Containment of all re- turn flows would increase dredging costs, dredge equipment, land purchase costs).	Additional land costs: \$44,000 dredging site development costs \$76,000 per 50,000 cu. yd.
2. More land needed for disposal sites. (displacement of farms)	Acres	Land used at most sites is just enough for disposal.	Same as present.	At most sites, additional land would be needed at least temporarily for re- tention of water.	More land needed for disposal.
3. Improved water quality.	Suspended sediment con- centration and turbidity.	Return flows frequently contribute more sus- pended solids and tur- bidity to the river.	Same as present.	Decrease in the suspended solids and turbidity of re- turn flows to the river.	
4. Fish and wildlife habitat.	1. Acres 2. Habitat quality.	Habitat degradation caused by dredge disposal return flows.	Same as present.	Less habitat degradation caused by dredge disposal return flows.	

RECOMMENDATION # 1

The States of Wisconsin, Iowa, Illinois and Minnesota with the aid of U.S. - EPA should have industrial waste pretreatment and recovery process in operation as soon as possible.

Pretreatment programs should consider the industrial waste pretreatment municipal sewerage systems of these cities as their first priority.

Dubuque, Iowa

Clinton, Iowa

East Moline, Alton and Rock Island, Illinois

Bettendorf and Davenport, Iowa

Muscatine, Iowa

Burlington, Iowa

Ft. Madison, Iowa

Keokuk, Iowa

Quincy, Illinois

Where possible, more effective waste treatment and/or recovery recovery should be accomplished with priority on these industrial discharges to the Mississippi. Significant pollutants are shown if known.

- John Deere and Company, Dubuque, Iowa (Chromium, Lead)
- Apple River Chemical, near E. Dubuque, Illinois
- E.I. DuPont DeNemours, Clinton, Iowa (Copper, Lead, Mercury, BOD)
- Hawkeye Chemical Company, Clinton, Iowa (Chromium, Nitrogenous waste)
- 3M Corporation, near Albany, Illinois (Iron, Copper, Zinc, Ammonia)
- John Deere and Company, E. Moline, Illinois (Oil and Grease)
- Monsanto Incorporated, Muscatine, Iowa (Herbicides, C.O.D.)
- First Mississippi Incorporated, near Ft. Madison, Iowa (Copper, Chromium, Nickel and Zinc)
- Consolidated Packaging Incorporated, Ft. Madison, Iowa (BOD)
- W. A. Sheaffer Pen Company, Ft. Madison, Iowa (Chromium)

Ammonia Plant Incorporated, near Ft. Madison, Iowa (BOD, Ammonia)

Chevron Chemical Company, near Ft. Madison, Iowa

H. J. Rogers Company, Keosauqua, Iowa (BOD, Ammonia)

W. H. H. Company, Keosauqua, Iowa

W. H. H. Company, Incorporated, near W. Quincy, Missouri (Nitrogen and Ethanol, Sewage)

June 26, 1979

Attachment #4  
W.Q. Work Group

DISPLAY OF RECOMMENDATION &  
PRELIMINARY IMPACT ASSESSMENT

Recommendation Number 5  
Pool Number All  
River Mile   
Date Approved by Work Group

1. General problem addressed (write out & use number from Attachment #1):
  - #18. Point source discharges contribute many pollutants to the river.
  - #25. Point source discharges in Ft. Madison, Iowa are degrading water quality.
  - #27. There may not be adequate coordination with w.q. management agencies in Iowa.
  - #29. Effluent from 3M Plant may be degrading water quality.
2. Sub-problem addressed (write out - use only when necessary):
3. Sub-objective addressed (taken from Attachment #2 - write out):

To characterize present water quality in the study area including spatial and temporal water quality trends, and locations and frequencies of water quality standards violations.
4. Tasks accomplished to address problem (taken from Attachment #3 - write out):

Write water quality assessment report.

Map point source discharges to the Mississippi.
5. Listing of alternatives to problem:
  - a. State w.q. management agencies and U.S. E.P.A. should promote more and better industrial pretreatment of wastes.
  - b. Industrial pretreatment of wastes remain at present levels.

6. Selected alternative a (write in the letter).
7. Rationale for selection of alternative: Several heavy metals in the Mississippi frequently are found in violation of either the drinking water standard, the aquatic life standard, or both. Municipal treatment plants are not designed for high efficiency metals removal. Metals in municipal treatment plants sludges can make them toxic and reduce their value as a soil conditioner.
8. References used to select alternative (use tasks, support documents and/or discussions, studies, articles, etc.):

Water quality assessment report, GREAT II.
9. Rationale for elimination of other alternatives:

If industrial pretreatment remains at present levels, the metals load to river will remain high and contribute to frequent violations of water quality standards.
10. Preliminary impact assessment of selected alternative. (List below all general impacts which can be identified by the work group. The level of detail required is only that for which the information is readily available.)
  1. Increased cost of pretreatment.
  2. Savings due to resource recovery through pretreatment process.
  3. Improved water quality, heavy metals, other industrial wastes.
  4. Improved water quality due to higher efficiency of treating organic wastes at municipal plants.
  5. Increased value of municipal sludge.
11. Reason for work group rejection of recommendation:

ATTACHMENT #7

RECOMMENDATION

5

RECOMMENDATION #

LOCATION (RIVER MILE)

IMPACT

ASSESSMENT FORM

POOL

All

1. LIST OF IMPACTS (SEE ATT. #4)	2. UNITS TO BE MEASURED IN	3. PRESENT CON- DITION AS OF JAN. 1, 1979 FOR EACH IMPACT	4. DESCRIPTION OF MOST PROB- ABLE FUTURE (2025) WITHOUT RECOMMENDATIONS	5. DESCRIPTION OF MOST PROBABLE FUTURE (2025) WITH RECOMMENDATIONS	6. MEASURE OF IMPACTS (COL. 5 COL. 4)
1. Increased cost of pretreatment for both government and industry.		Some resource recovery is practiced by certain industries but federal and state programs and guidelines for industrial pretreatment are minimal or non-existent.	Cost both for actual treatment and for administration of pretreatment programs will increase as more pretreatment is practiced and government programs expand. Estimated administration annual costs 1979-1983* Municipal costs/treatment plant \$16,000 State Administration costs state \$347,000 Costs industrial discharger \$368 Actual pretreatment costs: no estimate available.	Recommendations concerning which discharges and pollutants to be focused on, may lead to a greater degree of pretreatment than otherwise planned and thereby increase pretreatment costs. Administrative costs should be the same as for Col. 4. Treatment costs may be higher.	
2. Savings by industry through resource recovery.		Some resource recovery is practiced by certain industries.	Increased costs or reduced supplies of materials may make resource recovery through pretreatment more economical.	Same as future condition without recommendation.	

ATTACHMENT #7

RECOMMENDATION # 5 (continued)  
 LOCATION (RIVER MILE)  
 POOL ALL  
 RECOMMENDATION  
 IMPACT  
 ASSESSMENT FORM

1. LIST OF IMPACTS (SEE ATT. #4)	2. UNITS TO BE MEASURED IN	3. PRESENT CON- DITION AS OF JAN. 1, 1979 FOR EACH IMPACT	4. DESCRIPTION OF MOST PROB- ABLE FUTURE (2025) WITHOUT RECOMMENDATIONS	5. DESCRIPTION OF MOST PROBABLE FUTURE (2025) WITH RECOMMENDATIONS	6. MEASURE OF IMPACTS (COL. 5-COL.4)
3. Improved water quality.	Concentration of heavy metals and other indus- trial wastes in river water.	Such industrial wastes as - iron, - lead and - copper often exceed water quality standards in the Mississippi River.	Increased pretreat- ment should help de- crease the loading of industrial wastes from existing point sources.	Recommendations by GREAT should focus on which in- dustrial pollutants are of most concern in the Mississippi and thereby address the most critical water quality problems.	
4. Improved water quality due to higher efficiency of treating or- ganic wastes at municipal treat- ment plants.	Concentrat of BOD, and amm in river ter.	Periodic slugs of metal rich influent at municipi- pal treatment plants can be toxic to micro- organisms in the sewage treatment process. The reduced activity or in- activity of the micro- organisms due to metal or other toxic industrial waste reduced the treat- ment efficiency of the plant.	Improvement in overall treatment plant efficiency due to fewer toxicity problems from industrial wastes.	Same as future condi- tion without recommendation, but may occur sooner with recommendation.	

ATTACHMENT #7

RECOMMENDATION

RECOMMENDATION # 5 (continued)

IMPACT

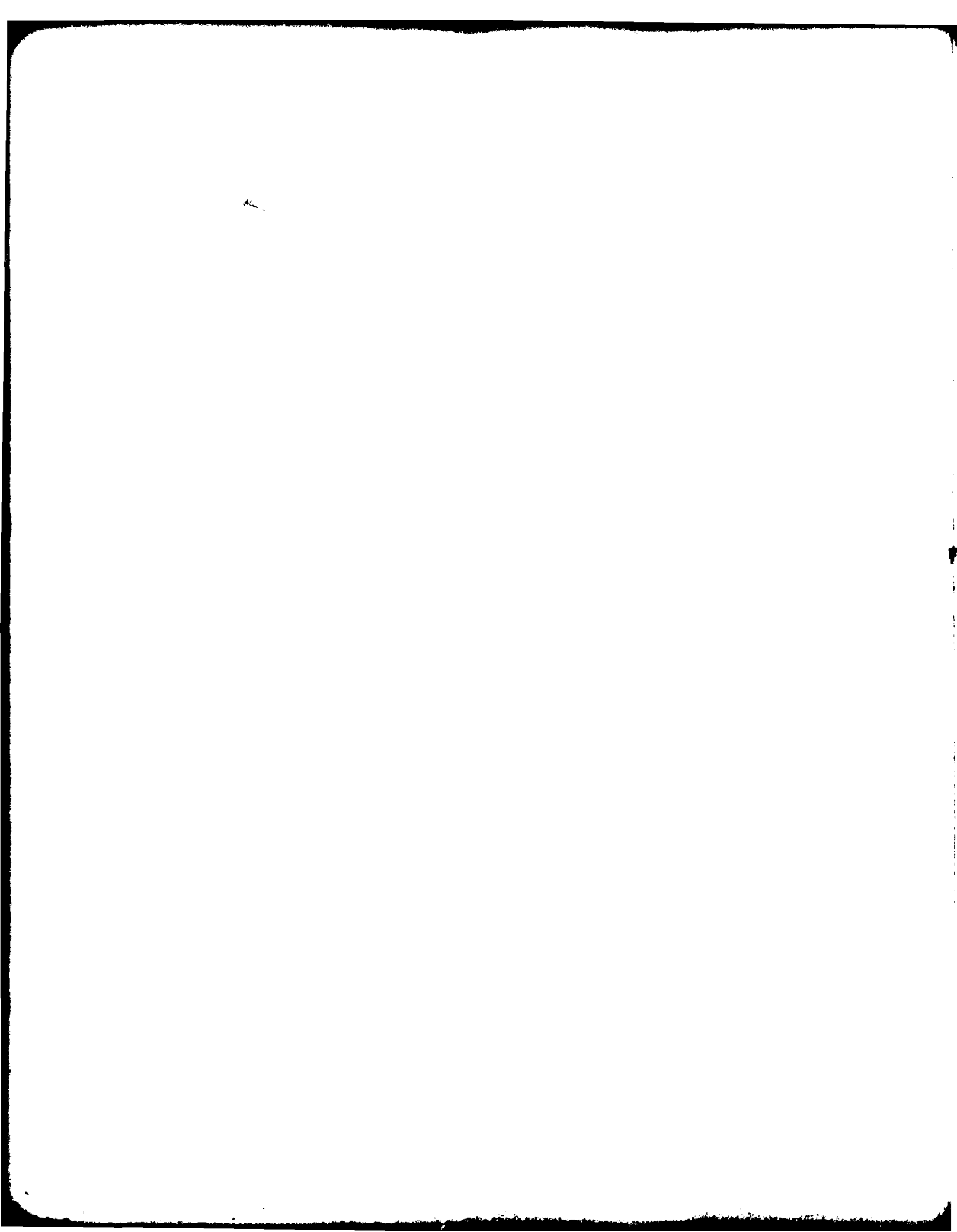
LOCATION (RIVER MILE) \_\_\_\_\_

ASSESSMENT FORM

POOL All

1. LIST OF IMPACTS (SEE ATT. #4)	2. UNITS TO BE MEASURED IN	3. PRESENT CON- DITION AS OF JAN. 1, 1979 FOR EACH IMPACT	4. DESCRIPTION OF MOST PROB- ABLE FUTURE (2025) WITHOUT RECOMMENDATIONS	5. DESCRIPTION OF MOST PROBABLE FUTURE (2025) WITH RECOMMENDATIONS	6. MEASURE OF IMPACTS (COL. 5-COL.4)
5. Increased value of municipal sludge, or lower cost of disposal.	\$	Municipal sludges from large cities have low value due to toxic metal wastes. Most are either incinerated or burned in landfills.	Value of sludges, particularly as soil conditioners will increase as levels of metals in sludges decrease. Conven- tional disposal methods to land application should save an estimated \$35.00 per metric ton.*	Same as future condition without recommendation, but may occur sooner with recommendation.	
6. Protection of fish and wildlife habitat.	Habitat quality.	Some degradation of habitat by toxic materials.	Mitigation of toxic effects should gradually occur.	Mitigation should occur at faster rate.	

\*Federal Register: General Pretreatment Regulations for Existing and New Sources of Pollution,  
Monday, June 26, 1978, Part IV EPA



RECOMMENDATION # 6

The water quality management activities of the states of Wisconsin, Iowa, Illinois, and Missouri should treat the Upper Mississippi River as an entity and not as an aggregate of political units. Although various segments of the river differ and may require different standards or use designations, the adjoining states along any given segment of the river should be consistent in their management to this degree:

- identical water quality standards for that segment (identifying and protecting the same beneficial uses).
- similar limitations on the concentration of pollutants in discharges to the river. As a general rule, effluent limits for one state should not exceed those of the adjoining state by more than 100%.
- identical chlorination policies.
- state water pollution control agencies should encourage U.S. E.P.A. through the State-EPA agreement process to conduct a waste load allocation study for the Upper Mississippi River.

This recommendation should be considered at the 1980 or 1981 national meeting of the Association of State Water Pollution Control Administrators (ASWPCA), or at a meeting specially convened and attended by the Water Pollution Control Administrators for the four states involved.

June 26, 1979

Attachment #4  
W.Q. Work Group

DISPLAY OF RECOMMENDATION &  
PRELIMINARY IMPACT ASSESSMENT

Recommendation Number 6  
Pool Number All  
River Mile --  
Date Approved by Work Group

1. General problem addressed (write out & use number from Attachment #1):

- #5. It is not known whether legislative and institutional arrangements are adequate to successfully manage water quality.
- #9. Impact of point sources on water quality is unknown and hinders proper w.q. management.
- #12. Pollution due to dredging practices and disposal of dredge materials is occurring.
- #18. Point source discharges contribute many pollutants to the river.
- #25. Point source discharges in Ft. Madison are degrading water quality.
- #26. Farm chemicals and sedimentation are degrading water quality.
- #29. Effluent from 3M Plant may be degrading water quality.
- #32. Thermal pollution caused by discharge from nuclear plants may degrade w.q.

2. Sub-problem addressed (write out - use only when necessary):

3. Sub-objective addressed (taken from Attachment #2 - write out):

Promote the formation of a uniform set of guidelines for all agencies involved in water quality management in the study area.

4. Tasks accomplished to address problem (taken from Attachment #3 - write out):

Write a water quality assessment report.

Assessment of dredge disposal related water quality problems.

Lab simulation of desorption of pollutants.

5. Listing of alternatives to problem:
  - a. Develop compatible w.q. management regulations for the Mississippi River agreeable to all states in the study area.
  - b. Continue to have each state set its own water quality standards and effluent limitations on the Mississippi.
6. Selected alternative a (write in the letter).
7. Rationale for selection of alternative: The best interests of the river resource management will be served only when the river is recognized and managed as an entity rather than an aggregate of political units.
8. References used to select alternative (use tasks, support documents and/or discussions, studies, articles, etc.):

Discussions with personnel from RII/COE, U.S. F.W.S., U.S. E.P.A. and the various state w.q. management agencies.
9. Rationale for elimination of other alternatives:

Separate state standards hinder interagency and interstate cooperation in reaching w.q. management goals.
10. Preliminary impact assessment of selected alternative. (List below all general impacts which can be identified by the work group. The level of detail required is only that for which the information is readily available.)
  1. Costs of interagency/interstate w.q. management activities.
11. Reason for work group rejection of recommendation:

ATTACHMENT #7

RECOMMENDATION

IMPACT

ASSESSMENT FORM

RECOMMENDATION # 6

LOCATION (RIVER MILE)                     

POOL ALL

1. LIST OF IMPACTS (SEE ATT. #4)	2. UNITS TO BE MEASURED IN	3. PRESENT CON- DITION AS OF JAN. 1, 1979 FOR EACH IMPACT	4. DESCRIPTION OF MOST PROB- ABLE FUTURE (2025) WITHOUT RECOMMENDATIONS	5. DESCRIPTION OF MOST PROBABLE FUTURE (2025) WITH RECOMMENDATIONS	6. MEASURE OF IMPACTS (COL. 5-COL. 4)
1. Cost of inter- agency w.q. management acti- vities, i.e. con- flict resolution, formation of interstate com- tracts or memo- randa of agree- ment.	\$	States have devel- oped separate stan- dards use designations and levels of protec- tion for the Upper Mississippi River.	Separate standards and levels of pro- tection will be en- forced by w.q. management agencies on the river. River not managed as a single resource.	Upper Mississippi managed as a single entity with similar standards for river and discharge effluent standards. Interagency w.q. management activities simplified and less costly.	
2. Cost of water quality standards and regulations revision.	\$	Regular review and revision of standards occurs every 3 years as part of each states' continuing planning activities.	Standards, revision process will con- tinue on a once in 3 year basis.	Recommendation would be incorporated into the ex- isting standards revision process.	\$0.00
3. Cost of waste load allocation study.	\$	No such study is being made.	Same as present.	Money would be spent to conduct study.	
4. Protection of water quality.	Soundness of w.q. manage- ment decisions.	The quality rather than the quantity of pollu- tants discharged to the river is the primary con- cern of w.q. management agencies.	Same as present.	There will be information on total pollutant load river is capable of accepting without causing chronic and extensive water quality stan- dards violations.	

RECOMMENDATION # 7

All NPDES permit holders in the GREAT II study area required to submit quarterly thermal monitoring reports should use a standardized reporting format. The process of heat dispersion is well understood, and adequate site specific mathematical models have been developed for some power plants. It is recommended that all NPDES permit holders who must file quarterly monitoring reports develop a mathematical model of heat dispersion of their effluent in the Mississippi River. The model should be able to predict the following attributes of the thermal plume:

- length, width and depth of the 5°F over ambient thermal plume.
- the percent of the river cross-section passing through the 5°F over ambient plume.
- the percent of river flow passing through the 5°F over ambient plume.

June 26, 1979

Attachment #4  
W.Q. Work Group

DISPLAY OF RECOMMENDATION &  
PRELIMINARY IMPACT ASSESSMENT

Recommendation Number 7  
Pool Number All  
River Mile   
Date Approved by Work Group

1. General problem addressed (write out & use number from Attachment #1):
  - #1. There is a lack of coordinated water quality and sediment quality data in the study area.
  - #9. The impact of point sources on water quality is unknown.
  - #32. Thermal pollution caused by discharge from nuclear plants may degrade water quality.
2. Sub-problem addressed (write out - use only when necessary):
3. Sub-objective addressed (taken from Attachment #2 - write out):

Assess the effectiveness of present water quality monitoring programs with study area.
4. Tasks accomplished to address problem (taken from Attachment #3 - write out):

Write a water quality assessment report.
5. Listing of alternatives to problem:
  - a. Require that all thermal monitoring reports submitted for waters discharged to the Mississippi River in the GREAT II study area have an identical format which includes (as a minimum) the length, width and depth of the 5° F over ambient thermal plume(s), an estimate percent of river cross section, and the percent of river flow passing through the plume. All NPDES permit holders required to submit thermal monitoring reports should be encouraged to develop predictive models which can estimate plume size on critical days within the reporting period.
  - b. Make no change in present reporting procedures.

6. Selected alternative   a   (write in the letter).
7. Rationale for selection of alternative: Present thermal monitoring reports have different formats and often do not present complete information on the most important problems. Standardizing the format for essential parts of the report guarantees that the reports will accomplish the purposes intended.
8. References used to select alternative (use tasks, support documents and/or discussions, studies, articles, etc.):

Thermal monitoring reports for power plants in the GREAT II-III study area.

9. Rationale for elimination of other alternatives: Present monitoring procedures, particularly at the Quad City Nuclear Plant when discharge from the intake fore bay occurs, do not define the thermal plume dimensions. The percent of river passing through the plume and the percent of river cross section are factors with important biological implications that are not measured at most power plants.
10. Preliminary impact assessment of selected alternative. (List below all general impacts which can be identified by the work group. The level of detail required is only that for which the information is readily available.)
  1. Increased monitoring costs.
  2. Increased knowledge of thermal discharges.
11. Reason for work group rejection of recommendation:



RECOMMENDATION # 8

A group of water quality monitoring stations should be established below a major urban area within the GREAT II study segment (Quad Cities is recommended). This group of stations will be used to assess the impact of the discharges of a large urban area on water quality in the Mississippi River. Such a study would be an integral part of any wasteload allocation project for the Mississippi. Therefore, it is recommended that this monitoring program be implemented by U.S. E.P.A.

Study design should provide for at least four stations that will show the rate and spatial extent of the recovery and/or dispersion process. Water quality variables to be monitored should include as a minimum: temperature, pH, conductivity, DO, BOD, COD,  $\text{NH}_3\text{-N}$ ,  $\text{NO}_2\text{+NO}_3\text{-N}$ , Total P, total filterable P, FC, and the total and dissolved fractions of these metals: iron, manganese, cadmium, chromium, copper, lead, zinc, and mercury.

June 26, 1979

Attachment #4  
W.Q. Work GroupDISPLAY OF RECOMMENDATION &  
PRELIMINARY IMPACT ASSESSMENT

Recommendation Number 8  
 Pool Number 16  
 River Mile All  
 Date Approved by Work Group

1. General problem addressed (write out & use number from Attachment #1):
  - #1. There is a lack of coordinated water quality and sediment quality data in the study area.
  - #9. The impact of point sources on water quality is unknown and hinders proper management of water quality.
  - #17. Urban runoff is contributing sediment, O & G. organics and other pollutants to the river.
  - #18. Point source discharges contribute many pollutants to the river.
2. Sub-problem addressed (write out - use only when necessary):
3. Sub-objective addressed (taken from Attachment #2 - write out):
 

Assess the effectiveness of present water quality monitoring programs in the study area.
4. Tasks accomplished to address problem (taken from Attachment #3 - write out):
 

Develop recommendations for final report consistent with W.Q.W.G. objectives.
5. Listing of alternatives to problem:
  - a. Develop a group of ambient w.q. monitoring locations below a major urban area in the GREAT II study area to assess urban point and nonpoint source pollutant impacts on river water quality.
  - b. Continue to use only widely spaced ambient monitoring locations and do not attempt to measure urban pollution effects on the river.

6. Selected alternative a (write in the letter).
7. Rationale for selection of alternative: The large federal, state, and local government investments and those of the private sector in water pollution control need to be tied, in some rational manner, to existing water quality and our knowledge of how it is affected by pollutant sources.
8. References used to select alternative (use tasks, support documents and/or discussions, studies, articles, etc.):  

Task #5: Develop recommendations for final report consistent with W.Q.W.G. objectives.
9. Rationale for elimination of other alternatives: Other alternatives do not provide adequate data to evaluate the impact of urban point and nonpoint pollution on the Mississippi in the GREAT II area.
10. Preliminary impact assessment of selected alternative. (List below all general impacts which can be identified by the work group. The level of detailed required is only that for which the information is readily available.)
  1. Increased ambient monitoring costs.
  2. Increased knowledge of urban point/nonpoint pollutant impacts on river.
11. Reason for work group rejection of recommendation:

ATTACHMENT #7

RECOMMENDATION

RECOMMENDATION # 8

IMPACT

LOCATION (RIVER MILE) 16

ASSESSMENT FORM

POOL All

1. LIST OF IMPACTS (SEE ATT. #4)	2. UNITS TO BE MEASURED IN	3. PRESENT CON- DITION AS OF JAN. 1, 1979 FOR EACH IMPACT	4. DESCRIPTION OF MOST PROB- ABLE FUTURE (2025) WITHOUT RECOMMENDATIONS	5. DESCRIPTION OF MOST PROBABLE FUTURE (2025) WITH RECOMMENDATIONS	6. MEASURE OF IMPACTS (COL. 5-COL. 4)
1. Increased ambient monitoring costs.	\$	At present there is no such group of nearby stations.	Same as present.	Costs for operating such a network could be be- tween \$27,000-36,000/yr.	A cost of \$27,000- 36,000 per year.
2. Increased know- ledge of urban point source dis- charges on the river.	W.Q. mgmt. skills.	Present structure of W.Q. monitoring net- work allows minimal information on w.q. as affected by pollution sources from a single urban area.	Same as present.	Improved knowledge of the profundity of the pollution and the rate of river w.q. recovery from the pollution.	

RECOMMENDATION # 9

An on-site inspection attended by the RID/COE and officials of the Savanna Proving Grounds shall precede any disposal of dredge materials on the Savanna Proving Grounds.

June 26, 1979

Attachment #4  
W.Q. Work Group

DISPLAY OF RECOMMENDATION &  
PRELIMINARY IMPACT ASSESSMENT

Recommendation Number 9  
Pool Number 13  
River Mile 545.2-558.5  
Date Approved by Work Group \_\_\_\_\_

1. General problem addressed (write out & use number from Attachment #1):  
#12. Pollution due to dredging and dredge disposal practices is occurring.
2. Sub-problem addressed (write out - use only when necessary):
- 3/ Sub-objective addressed (taken from Attachment #2 - write out):  
Provide for mitigation of the adverse water quality effects of dredging and dredge disposal during the period prior to development of final w.q. criteria for dredging and disposal.
4. Tasks accomplished to address problem (taken from Attachment #3 - write out):  
Develop recommendations for final report consistent with work group objectives.
5. Listing of alternatives to problem:
  - a. Prohibit disposal at Savanna Proving Grounds.
  - b. Require on-site inspection by personnel from COE & SPG prior to placement of dredge spoils on SPG to insure disposal activities do not impact materials stored at site.
  - c. Follow same format for disposal as is normally observed at other disposal site.
6. Selected alternative b (write in the letter).
7. Rationale for selection of alternative: Inspection of the area by COE & SPG officials should insure that disposal and return flows will not come in contact with materials stored at site. The Proving Grounds are out of the floodplain so that erosion of spoils back into the river should be negligible.

8. References used to select alternative (use tasks, support documents and/or discussions, studies, articles, etc.):

Discussion with personnel of RID/COE, state w.q. management agencies and PFWG.

9. Rationale for elimination of other alternatives: Rejecting the site would disallow an otherwise suitable, out of the floodplain, disposal site. Not taking the precaution of an on-site inspection might increase the risk of contaminating return flows with hazardous or toxic materials stored at site.
10. Preliminary impact assessment of selected alternative. (List below all general impacts which can be identified by the work group. The level of detail required is only that for which the information is readily available.)
  1. Decreases risk of water quality degradation by materials stored at site.
11. Reason for work group rejection of recommendation:

ATTACHMENT #7

RECOMMENDATION

IMPACT

ASSESSMENT FORM

RECOMMENDATION # 9

LOCATION (RIVER MILE) \_\_\_\_\_

POOL 13

1. LIST OF IMPACTS (SEE ATT #4)	2. UNITS TO BE MEASURED IN	3. PRESENT CON- DITION AS OF JAN. 1, 1979 FOR EACH IMPACT	4. DESCRIPTION OF MOST PROB- ABLE FUTURE (2025) WITHOUT RECOMMENDATIONS	5. DESCRIPTION OF MOST PROBABLE FUTURE (2025) WITH RECOMMENDATIONS	6. MEASURE OF IMPACTS (COL. 5-COL. 4)
1. Decrease risk of water quality de- gradation by materials stored at SPG.		No spoils have been placed at the SPG but it is being considered as a potential dis- posal site.	On-site inspection by COE & OSIT should reduce the risk of degradation of water quality due to contamination of return flow by mat- erials stored at SPG.	Risk of w.q. degradation by materials stored at site is further reduced if SPG officials are included in the on-site inspection team at this site.	
2. Cost of in- spection.	\$	Corps of Engineers personnel inspect dis- posal sites prior to dredging.	Same as 3	SPG personnel also would have to be present at site inspection. 2 man/days at \$20/man hour.	Additional cost estimated at \$320.00

Table ii





# IMPACT ASSESSMENT SUMMARY

Water Quality WORK GROUP

## RECOMMENDATION NUMBER

IMPACTS	1	2	3	4	5	6	7	8	9
1. Noise									
2. Displacement of People									
3. Aesthetic Values									
4. Community Cohesion									
5. (Desired) Community Growth									
6. Tax Revenues									
7. Property Values									
8. Public Facilities									
9. Public Services									
10. (Desired) Regional Growth									
11. Employment/Labor Force									
12. Business/Industrial Activity									
13. Displacement of Farms									
14. Man-Made Resources									
15. Natural Resources									
16. Air Quality									
17. Water Quality/Quantity									

### KEY

-  Significant Direct Impact
-  No Direct Impact, Indirect Impacts May Need Further Assessment
-  Negligible Direct Impact
-  No Direct Impact

**NOTE:** Significant Direct Impacts and Indirect Impacts which may need further assessment are shown and measured on Attachment 7.

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**12**

## V. SUMMARY

### PROBLEM 1:

Lack of Coordinated Water Quality and Sediment Data in Study Area on Which to Base Management Decisions.

#### Sub-objective(s):

- To characterize present water quality in the study area.
- To assess the effectiveness of present water quality monitoring programs in the study area.

#### Task(s):

Write a report on water quality in the study area.

#### Results and Conclusions of Task(s):

The water quality assessment report summarizes water quality data from several sources and notes which pollutants in which locations exceed quality standards. The report also discusses present monitoring activities.

#### Recommendations:

- #7. Require NPDES thermal monitoring reports to have a standardized reporting format.
- #8. Develop a group of ambient water quality monitoring locations below a major urban area.

#### Implementation and Requirements

- Recommendation #7 will require coordination between EPA Regions V and VII and the Missouri DNR. Due to the biological significance of thermal discharges the U.S. Fish and Wildlife Service and the various state conservation agencies may wish to provide input into a proposed format.

Recommendation #8 would best be accommodated by EPA or a state water pollution control agency. The grouping of stations does not fit the conceptual framework of

NASQAN stations run by the U.S. Geological Survey. Since no large urban areas within the study area are located in Wisconsin or Missouri, either Iowa, Illinois or U.S. E.P.A. appear to be the agencies best suited for implementation. A group of four stations should be established with vertically integrated sampling at several points in the river cross section at each location. Spacing of stations should be based on a reconnaissance sampling program which defines the zone of recovery from pollution. No other large pollutant sources or major tributary should enter the segment bounded by the monitoring locations.

#### Unaddressed Problems, Future Needs

The most important data needs are those which keep us from basing important water quality management decisions on actual water quality problems. Foremost in terms of fiscal importance are data needs tying wastewater treatment to in-stream water quality.

### PROBLEM 2:

There Is a Lack of Data Pertaining to Surface and Groundwater Quality as It is Affected by Dredging and Disposal, on Which to Base Management Decisions.

#### Sub-objective(s):

- Develop modeling procedures that will predict the water quality impacts of dredging and dredge disposal on a site-specific basis.

#### Task(s):

- Assessment of dredge disposal related water quality problems.
- Lab simulation of desorption of pollutants from sediments.

#### Results and Conclusions of Task(s):

Modeling of Suspended Sediment Plumes. Return flows at the Rock Island and Keithsburg

sampling sites showed increases in suspended sediments of up to 75 mg/l over ambient levels in the river. There was no discernible return flow at Hannibal. Sand-sized material settled within the first 100 meters and silt-sized particles, generally within 400 to 500 meters.

The Schubel-Carter model and the Weschler-Cogley model were evaluated for accuracy and ease of use. The Schubel-Carter model, originally developed for estuaries, was modified to work on conditions more typical of the Upper Mississippi. This model has proved to be awkward in its solution and was not recommended for consideration. The Weschler-Cogley model has more promise and can utilize "plane" as well as "point" sources of suspended material. A "plane" source is a more accurate description of side bank or beach nourishment disposal than a "point" source. A third model is being developed by Sayre. The final report will contain 27 solutions for the Weschler-Cogley model, representing a variety of conditions, and a user manual.

**Lab. Desorption of Pollutants:** Three sediment samples, each from 10 sites, were analyzed as was river water and elutriates. At some sites there was considerable variation in the size and character of the pollutants. As expected, sandy sediments were generally very low in pollutants and finer sized sediments somewhat higher. In general, ammonia, COD, manganese and sometimes oil and grease, cadmium and zinc were desorbed from sediments. Iron, phosphate and copper seemed to adsorb to sediments during elutriate tests.

Water quality standards violations in elutriates occurred infrequently. The secondary drinking water standard for manganese was occasionally exceeded.

#### Recommendations

#2-RID/COE should use mathematical models developed by WQWG GREAT II to supplement their documentation of water quality effects of dredging.

#### Implementation and Requirements:

The models should be verified by RID/COE during two dredging operations in 1980 and two dredging operations in 1981.

#### Unaddressed Problems, Future Needs

- None of the work which was done addressed groundwater quality.
- The models developed in GREAT II must be evaluated as predictors of water quality impacts associated with dredging and disposal. It is anticipated that further refinement of the models will be needed since the data base for the development of the models was not large. Model verification is anticipated in the GREAT III study.

#### PROBLEM 3:

There is a Lack of Data on the Effect of Navigation on Water Quality, on Which to Base Management Decisions.

- The problem and future research needs are being addressed by GREAT I.

#### PROBLEM 4:

Operation and Maintenance of the 9-Foot Channel May Contribute to the PCB Problem.

#### Sub-objective(s):

- To characterize present water quality in the study.
- Develop modeling procedures that will predict the water quality impacts of dredging.

#### Task(s):

- Lab simulation of desorption of pollutants.
- Write a water quality assessment report.

#### Results and Conclusions:

- Mississippi River sediments sampled for elutriate testing contained negligible amounts of PCBs. There was no detectable increase in PCB concentration in elutriate over concentrations in ambient river water. The conclusion is that any PCB problem in the GREAT II Study Area is not measurably affected by channel maintenance.

#### Resultant Recommendations: None.

#### Implementation and Requirements: None.

### Unaddressed Problems, Future Needs

PCBs in the Mississippi are primarily a problem due to their accumulation in biota in levels that can be toxic to the animals involved and to humans who consume them. Present levels in Mississippi River fish have been documented in the water quality report. Periodic testing of Mississippi River fish flesh for PCBs should continue.

### PROBLEM 5:

It is Not Known Whether Legislative and Institutional Arrangements are Adequate to Successfully Manage Water Quality.

#### Sub-objective(s):

Assess the effectiveness of present water quality monitoring programs in the study area.

Promote the formation of a uniform set of guidelines for all agencies involved in water quality management in the study area.

#### Task(s):

Develop recommendations for final report consistent with final water quality objectives.

### Results and Conclusions:

No work group studies were conducted which pertained to this problem. Recommendations were developed through review of present management systems and discussion with personnel from many agencies involved in river resource management.

### Recommendations:

- #1. Water quality criteria for dredging and dredge disposal should be developed.
- #2. The COE should improve their water quality assessment capability.
- #3. States, with the help of the U.S. E.P.A., should initiate or strengthen industrial waste pre-treatment programs.

- #6. The states of Wisconsin, Iowa, Illinois and Missouri should develop compatible water quality management regulations so that best management practices are not hampered by political boundaries.

### Implementation and Requirements:

- Recommendation #1 has already been partially implemented. Specific levels for most variables have been established by U.S. E.P.A. A criterion has not been established for COD, and the solids and turbidity (sediment) criterion needs work before it will have any practical value in rivers. The question of whether an absolute sediment standard or a "floated" standard of so many parts per million of ambient should be used, must be addressed.
- Recommendation #2 is being initiated in GREAT II and GREAT III. At the start of GREAT III, the various state and federal water quality management agencies should advise the Corps on whether further refinement of the model is desired. If so, the COE should continue this work through a competent contractor.
- Recommendation #3 is being initiated in many states. Both U.S. E.P.A. funding and state agency manpower commitments are required.
- Recommendation #6 should be a function of the Upper Mississippi River Basin Commission (UMRBC).

### Unaddressed Problems, Future Needs:

Problems and needs arising from river river resource management should be addressed by the UMRBC.

### PROBLEM 6:

Shipment of Hazardous Material Affects Water Quality.

This problem was not addressed by the work group. Commercial transportation is a major function of the U.S. Coast Guard on the Mississippi.

#### PROBLEM 7:

Collection and Treatment of Wastewaters in the Twin Cities Has an Adverse Impact on Water Quality in the Study Area.

This problem was not appropriate to the scope of GREAT II and was not addressed in detail. PCB contamination was addressed in the water quality report and PCBs were measured in the lab simulation tests.

#### PROBLEM 8:

Waterfront Development Activities Have an Adverse Impact on Water Quality.

This problem was felt to be more appropriate to State 208 planning than to river management. Initial 208 planning for inventory of pollution sources, and formation of abatement plans has already occurred in most states.

#### PROBLEM 9:

The Impact of Point Sources on Water Quality Is Unknown. This Hinders Proper Management of Water Quality.

##### Sub-objective(s):

- To characterize present water quality in the study area.
- Assess the effectiveness of present water quality monitoring programs in the study area.

##### Task(s):

- Write an assessment report of present water quality in the study area.

Identify and map location of all direct point source discharges to the Mississippi River in the study area.

Develop recommendations for final report consistent with water quality objectives.

##### Results and Conclusions:

Existing water quality data yielded some discernible trends relating large urban pollution loads and in stream water quality. The

most obvious included: contamination of fish flesh below Minneapolis-St. Paul and below St. Louis, increase in frequency of high iron levels below St. Louis and high bacterial levels below the Illinois River. The spacing of sampling locations was too great to show all but the most obvious cases of water pollution from urban areas.

##### Resultant Recommendations:

- #8. Develop a group of water quality monitoring locations below a major urban area in the GREAT II study area that will measure the impact of the urban discharges on river water quality.

##### Implementation and Requirements:

Same as for problem #1.

##### Unaddressed Problems, Future Needs:

Same as for problem #1.

#### PROBLEM 10:

There Is Eutrophication in the Study Area.

##### Sub-objective(s):

- To characterize present water quality in the study area.

##### Task(s):

Write a report on water quality in the study area.

##### Results and Conclusions:

No studies of standing crop (biomass) or productivity rates of phytoplankton or aquatic macrophytes were made. The spatial water quality data show local nutrient increases in response to areas with large point source discharges and subsequent downstream assimilation of nutrients by the river biota. Over a 600-mile segment of the Upper Mississippi from Dubuque, Iowa, to Cairo, Illinois, there is a general trend of increasing  $\text{NO}_3\text{-N}$  and  $\text{PO}_4\text{-P}$  in the downstream direction. This trend indicates that assimilation by plants is not keeping pace with nutrient loading to the river. This trend may be not only a result of

increased nutrient loading in the St. Louis area, but also the reduction in standing crop of aquatic plants in the open river compared to the pooled portion of the river. Study of plant productivity in running water has heretofore presented too many difficulties to yield accurate results. However, work by Powers et al (1972) showed that nutrient additions to an already nutrient-rich lake did not promote additional algal productivity. Nutrient levels in the Mississippi are higher than those reported for the lake. Rivers also provide a continual and fairly rapid replacement of nutrients because they are moving waters. Therefore nutrient additions would appear to be less important in controlling plant productivity than light penetration or suitable substrate (aquatic macrophytes).

#### PROBLEM 11:

N.P.D.E.S. Permits May Require Rewriting to Adequately Protect Water Quality.

This problem is beyond the scope of the GREAT II study. The problem should be addressed by the issuing state or federal agency.

#### PROBLEM 12:

Pollution Due to Dredging Practices and Disposal of Dredge Materials Is Occurring.

##### Sub-objective(s):

- Develop modeling procedures that will predict water quality impacts of dredging and dredge disposal on a site-specific basis.
- Provide for mitigation of the adverse water quality effects of dredging and disposal during the period prior to development of final water quality criteria for dredging and disposal.

##### Task(s):

- Assessment of dredge disposal-related water quality problems.
- Lab simulation of desorption of pollutants.
- Develop recommendations for final report consistent with WQWG objectives.

#### Results and Conclusions:

Same as Problem #2.

#### Resultant Recommendations:

- #2. The COE should improve their water quality assessment capabilities using mathematical modeling based upon data collection and existing model modifications undertaken by the Great Study.
- #3. Stabilize spoils at locations out of the floodplain.
- #4. Require complete containment of water on-site until return flows are at least of equal quality with water in the river.
- #9. Require on-site inspection by personnel from RID/COE and Savanna Proving Grounds (SPG) prior to placement of any dredge spoils on the SPG.

#### Implementation and Requirements:

- For Recommendation 2: same as for problem #5.
- For Recommendation 3: The RID/COE with the assistance of the GREAT II Channel Maintenance Task Force and On-Site Inspection Team should secure and use out of the floodplain disposal sites for all deposition of spoils. Placement at the site should ensure minimal movement of material due to erosion.
- For Recommendation 4: Rough estimation of dredge spoils and water volumes will be required to issue adequate volume within retention structures. This work should be done by the RID/COE.

#### Unaddressed Problems, Future Needs:

Future refinement of predictive models for water quality impacts of dredging is anticipated.

PROBLEM 13:

Movement of Rivercraft Can Degrade Water Quality.

This problem is being addressed by GREAT I.

PROBLEM 14:

There Is Need For a Document Which Gives Comprehensive Data on Upper Mississippi River Water Quality.

Sub-objective(s):

To characterize present water quality in the study area.

Task(s):

Write a report on water quality in the study area.

Results and Conclusions of Tasks:

Same as for problem #1.

PROBLEM 15:

Upland Erosion Is Contributing Sediment to the River.

PROBLEM 16:

Streambank Erosion Is Contributing Sediment to the River.

This problem is being addressed by the Sediment and Erosion Control Work Group, GREAT II.

PROBLEM 17:

Urban Runoff Is Contributing Sediment, Oil and Grease, Organics and Other Pollutants to the River.

This problem is being addressed by state or designated area 208 plans developed under a section of the Federal Clean Water Law. The scope of the 208 effort is far beyond that to which GREAT II could be committed. Therefore, no involvement in this problem by GREAT II WQWG will occur.

PROBLEM 18:

Point Source Discharges Contribute Many Pollutants to the River.

Same disposition by WQWG as problem #9.

PROBLEM 19:

Accidental Spills, Including Shipment of Hazardous Materials, Pipeline and Railroad Spills, Degrade Water Quality in the River.

- Disposition of river transportation problems are the same as in problem #6.
- Spills from terrestrial transportation modes are under the jurisdiction of state water pollution control agencies and U.S. E.P.A. Spill response programs have been developed within those agencies.

PROBLEM 20:

Clamshell Dredging Creates High Levels of Turbidity.

This problem is not being addressed because of the limited amount of clamshell dredging that occurs in the study area. This topic was too low on the priority list for funding.

PROBLEM 21:

There Is Insufficient Understanding of How Water Quality Affects The Biota of the Keokuk Pool.

This is a problem requiring special studies. The Illinois Natural History Survey has conducted studies on an important member of the benthos, Musculium transversum. This problem was placed on the GREAT II list of proposed studies but was too low on the priority list for funding.

PROBLEM 22:

Recreational Boating.

Problem not addressed, too low on priority list for funding.

PROBLEM 23:

A Concise Bibliography Does Not Exist Which Compiles Research on the Effects of Naviga-

bar and Channel Maintenance on Water Quality.

Problem not addressed, too low on priority list for funding.

PROBLEM 24:

There Are Philosophical Differences as to How the River Should Be Used.

The problem is beyond the scope of the GREAT Study.

PROBLEM 25:

Point Source Discharges in Ft. Madison Are Degrading Water Quality.

Problem is addressed in the same manner as problem #9.

PROBLEM 26:

Farm Chemicals and Sedimentation Are Degrading Water Quality.

Sub objective(s):

Characterize present water quality in the study area.

Task(s):

Write an assessment report on present water quality in the study area.

Results and Conclusions:

Sediment and pesticide levels in the Mississippi change dramatically within the GREAT II study area. The more southerly section of the study area has much heavier sediment loads and a higher frequency of occurrence of pesticides. Non-point sources caused by soil erosion of agricultural origin on the Iowa, Manquoketa, Skunk, Des Moines, and Fabius River basins are the major sources. Sediment problems are primarily associated with the accelerated shoaling of backwater areas. Pesticides are not a threat to drinking water in the concentrations presently found. Fish flesh standards for Dieldrin and DDT have been established. Available

data show no problems with DDT accumulation in fish, but Dieldrin levels in fish on the Mississippi near Hannibal approach the standard. Although no fish flesh standard exists for it, bioaccumulation of chlordane may also be a problem. There are presently 10 locations on the UMR (2 within the GREAT II segment) where annual fish flesh sampling is done. This sampling should be adequate to provide information on trends in pesticide contamination of fish flesh.

Resultant Recommendation NONE

Implementation and Requirements: NONE

Unaddressed Problems and Further Needs:

The overall problem is reducing the loading of bioaccumulative pollutants at their source and the need to develop management systems to accomplish these reductions.

PROBLEM 27:

There May Not be Adequate Coordination with Iowa DEQ.

Sub-objective(s):

- Promote the formation of a uniform set of guidelines for all agencies involved in water quality management in the study area.

Task(s):

- Develop recommendations for the final report consistent with WQWG objectives.
- Participation in on-site inspection team, post disposal task force and water quality work group.

Results and Conclusions:

Communication with Iowa DEQ has been maintained throughout the study. It is felt that there will be adequate coordination of activities with Iowa DEQ.

Resultant Recommendations: None

Unaddressed Problems and Future Needs: None

PROBLEM 28:

Costs of Cleaning Up Effluent Are High.

This problem is outside the scope of the GREAT study.

PROBLEM 29:

Effluent From 3M Plant May be Degrading Water Quality and Should be Checked.

Same disposition as problem #9.

PROBLEM 30:

Commercial Barge Traffic Increases Bank Erosion and Turbidity.

Same disposition as problem #3.

PROBLEM 31:

U.S.E.P.A. Grants for Sewage Treatment Plant Construction Are Slow.

This problem is not within the scope of the GREAT study.

PROBLEM 32:

Thermal Pollution Caused by Nuclear Power Plant Discharges May Degrade Water Quality.

Sub-objective(s):

- Characterize present water quality in the study area.
- Assess the effectiveness of present water quality monitoring programs in the study area.

Task(s):

- Write an assessment of water quality in the study area.
- Identify and map locations of all direct point source discharges to the Mississippi in the study area.

Develop recommendations consistent with WQWG objectives.

Results and Conclusions:

The extent of thermal discharges to the Mississippi is not generally large. The maximum length of the 5°F increased temperature plume is about one mile and occupies only a fraction of the channel width. However, present monitoring formats generally do not measure variables important to ichthyoplankton survival. The Quad Cities Nuclear Plant does not measure plume dimensions when they exceed 500 feet in length.

Resultant Recommendation:

- #7. Require all thermal monitoring reports within the study area to have a standardized reporting format which includes as a minimum, the length, width and depth of the 5°F over ambient thermal plume(s) and an estimate of percent of river cross section and percent of river flow passing through this plume. All NPDES permit holders required to submit thermal monitoring reports should be encouraged to develop predictive models which can estimate plume size on critical days within the reporting period.

Implementation and Requirements:

Implementation would be the responsibility of the state or federal permit issuing authority.

Unaddressed Problems, Future Needs:

The major area of concern is the effect of thermal discharges on the total fisheries resource of the river. Killing of ichthyoplankton or adult fish occurs due to abrupt changes in river temperature associated with thermal discharges. However, until the actual size and nature of the fisheries of the Mississippi can be determined and compared to potential carrying capacity, the importance of these effects will not be known. Further research on actual fish population size versus carrying capacity is needed.

PROBLEM 33:

There Is Inadequate Knowledge of Flow Regimes to Predict the Movement of Pollution.

Same disposition as problems 2 and 9.

PROBLEM 34:

Municipal Water Plants Do Not Keep Detailed Enough Records to Evaluate Significant Water Quality Changes Over the Years.

This is not considered a problem since this kind of work is not a function of water treatment plant operation.

PROBLEM 35:

The Effects of Large Rainfalls Within the Basin on River Water Quality Is Not Well Known.

The large size and cost of such a research project is beyond the scope of GREAT. The state of the art in watershed research cannot presently deal with a watershed of this size.

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VI BIBLIOGRAPHY

Anderson, K.B. et al, 1977, "The Toxicity of Potassium, Undissociated Ammonia, and Illinois River Water to the Fingernail Clam, Musculium transversum." Presented at the 39th Midwest Fish and Wildlife Conference, Madison, Wisconsin. December 4-7, 1977.

Brannon, R.M. et al. (no date) "Distribution of Toxic Heavy Metals in Marine and Freshwater Sediments." Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi.

Great River Environmental Action Team I - Water Quality Work Group, 1978. "A Pilot Study on Effects of Hydraulic Dredging and Disposal on Water Quality of the Upper Mississippi River." U.S. Army Corps of Engineers, St. Paul, Minnesota.

Great River Environmental Action Team II - Water Quality Work Group, 1980. "Laboratory Simulation of Desorption of Pollutants From Dredge Materials published by Rock Island District Corps of Engineers, Rock Island, Illinois.

Johnson, J.H. 1976, "Effects of Tow Traffic on the Resuspension of Sediments and on Dissolved Oxygen Concentrations in the Illinois and Upper Mississippi Rivers under Normal Pool Conditions," U.S. Army Waterways Experiment Station, Vicksburg, Mississippi. Technical Report Y-76-1, 129 pp.

Powers, C.F., et al, 1972 "Algal Responses to Nutrient Additions in Natural Waters II: Field Experiments," in Nutrients and Eutrophication, G.E. Likens (Ed.), American Society of Limnology and Oceanography.

Rock Island District, U.S. Army Corps of Engineers, 1978, "Water Quality Analysis: 1978 Dredging Season." Rock Island District COE. Rock Island, Illinois, 1978.

Thompson, C.M. and R.E. Sparks, 1977, "Status of the Fingernail Clam, Musculium transversum, in the Keokuk Pool, Mississippi River." Presented at the 39th Midwest Fish and Wildlife Conference, Madison, Wisconsin, December 4-7, 1977.

VII ACCOMPANYING DOCUMENTS

- A. Water Quality Assessment Report.
- B. Minutes of Water Quality Work Group Meetings.
- C. Contract Reports. (published under separate cover)
  - 1. Dredge Disposal Return Flow Assessment: To be submitted by Contractor by January 1, 1980.
  - 2. Lab Simulation of Desorption of Pollutants: To be submitted by Contractor by January 1, 1980.

## A. Water Quality Assessment Report

### A SUMMARY AND DISCUSSION OF WATER QUALITY ON THE UPPER MISSISSIPPI RIVER

#### I. Introduction

This report addressed water quality in the Upper Mississippi River. While the confines of the GREAT II Study are the mainstem of the Mississippi between Guttenburg, Iowa and Saverton, Missouri, this report, of necessity, discusses a larger segment of the river and its major tributaries to better understand the observed water quality in the GREAT II segment. (See Figure 1.)

This report discusses general water chemistry, toxics, suspended sediment and water quality implications on fish resources of the river. Even though sediment and fisheries constitute separate GREAT II work groups, they are intimately associated with water quality, and both will be addressed in this report.

#### II. Major Ions

The Mississippi, like most fresh waters of the world, is a "bicarbonate water" since bicarbonate (especially calcium bicarbonate) is the predominant dissolved substance. Ruttner (1953) noted that bicarbonate waters worldwide have nearly identical proportions of major dissolved substances. A more recent summary by Wetzel (1975) shows greater variability in relative ion concentration but takes into account the volume contributed by such rivers as the Amazon whose waters have little contact with underlying geologic strata. It was noted by Hynes (1970) that it is a common trait of rivers to show an increase in concentration of major ions in the downstream direction. This conclusion holds true for the Mississippi. During W.Y. 1976, at Winona, Minnesota (UMR Mile 726) the average concentration of the seven major ions was approximately 240 mg/l, while at Thebes, Illinois (UMR Mile 44) it had increased to 410 mg/l. (USGS, 1976).

Noticeable effects on the major ion composition of the Mississippi are made by large

tributaries and possibly by large metropolitan areas such as St. Louis. The influence of these sources is shown in Table 1.

The Mississippi clearly becomes less a "bicarbonate type" river as it progresses downstream, particularly below the confluence of the Missouri. Major ion budgets (1975-1978) for the Missouri and the Mississippi above the Missouri, show that while the two rivers deliver approximately equal amounts of Ca, Mg, K,  $\text{HCO}_3$  and Cl, the Missouri contributes three times as much Na and  $\text{SO}_4$ . Thus, the relative importance of Ca, Mg and  $\text{HCO}_3$  is reduced at Thebes, but Cl is not, suggesting there are important sources of this ion other than the Missouri and Upper Mississippi Rivers.

#### III. Nutrient Ions

Although the dissolved solids load of the Mississippi is made up almost entirely of the seven major ions discussed in the preceding section, important plant nutrients such as phosphate, nitrate and ammonia are also in solution in small quantities. Whereas the seven major ions account for about 240 mg/l in the Upper Mississippi at Winona, Minnesota and over 400 mg/l at Thebes, Illinois, the total amount of N and P in the Mississippi is only 2 mg/l at Winona and about 2.5 mg/l at Thebes (USGS, 1976). The importance of these nutrients, however, far outweighs their small amounts. They are important building blocks of anabolic processes and products of catabolic processes. Their concentration fluctuates much more than the major ions, and this fluctuation is valuable in indicating the entry of organic pollutants into the river and their changes in form or assimilation by aquatic biota. The downstream changes in concentration of these nutrient ions reflect more complicated processes than those which affect major ion concentration. In his discussion of this subject, Hynes (1970) was able to reference two studies on large rivers

Figure 1  
UPPER MISSISSIPPI RIVER BASIN

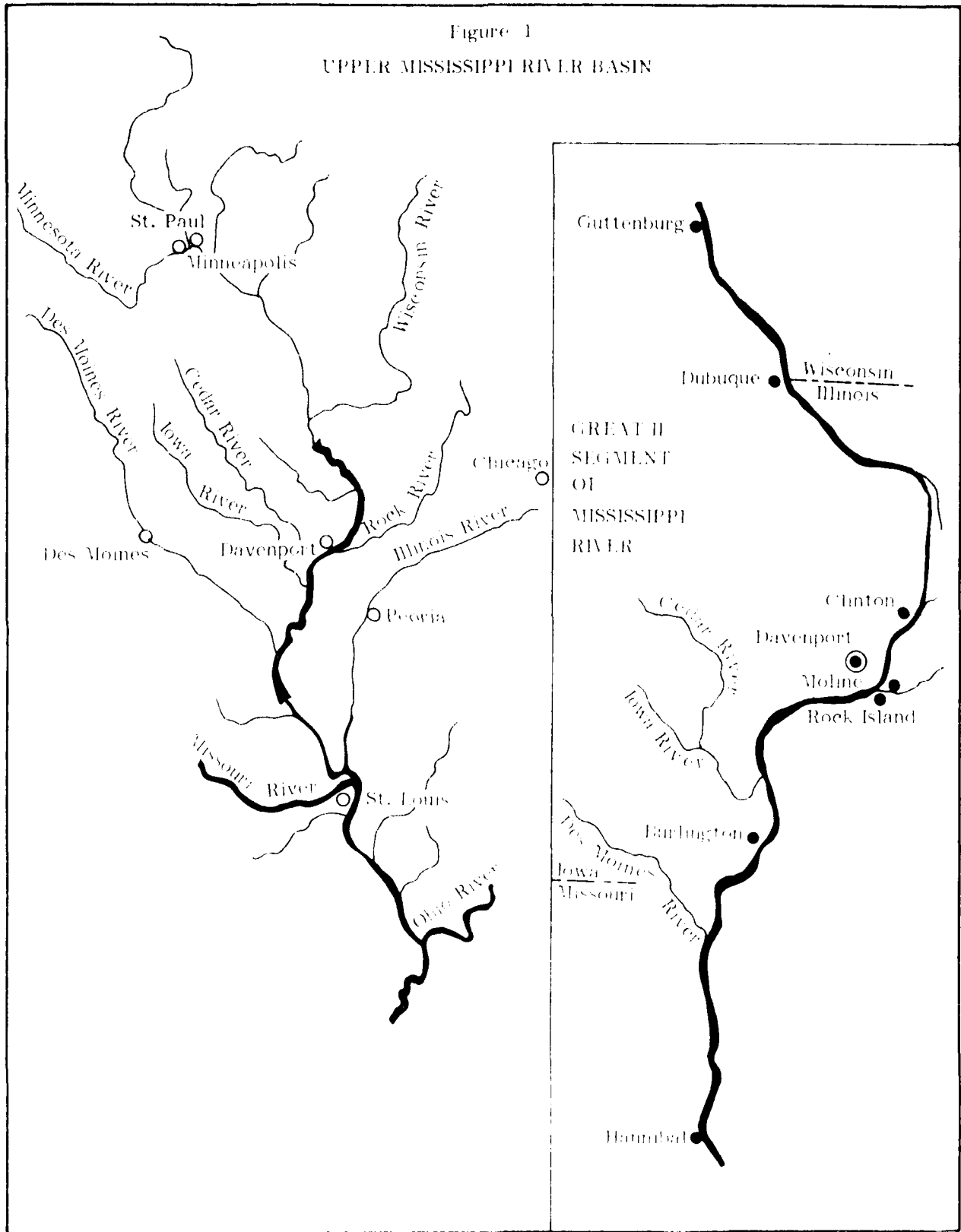


TABLE 1  
RELATIVE PROPORTIONS OF MAJOR IONS IN MISSISSIPPI (1976)  
(percent)

Location	Ca	Mg	Na	K	HCO <sub>3</sub>	SO <sub>4</sub>	Cl
Winona, MN	18	11	8	1	52	4	6
Thebes, IL	16	10	17	1	38	12	6

where significant reductions in nutrient ions were caused by biological activity. However, he makes no general statement on downstream trends in nutrient ion concentration except that nutrients are apparently taken up and recycled quickly through plants back to the stream and that local conditions exert the most influence.

Table 2 and Figure 2 show the variation in concentration of nitrogen and phosphorus in the form of nitrate, ammonia and phosphate between Guttenburg, Iowa and Cairo, Illinois, as measured by the Illinois EPA and USGS.

Figure 3 shows that when large point source BOD<sub>5</sub> loads and the confluences with major tributaries are added to the information in Figure 2, they match up very well with the observed spatial variation in average nutrient concentration. River segments between adjacent water quality stations which show a decreasing trend in nutrient concentration do not contain large point source discharges. Conversely, all segments with large point source discharges show increased nutrient concentration at the downstream end of the segment. The influence of the Wapsipineon, Rock, Skunk and Des Moines Rivers is masked by large point source discharges in the same segment. The Iowa River is evidently similar in concentration to the Mississippi, below Muscatine, since no change in concentration is noted. The effect of the Illinois and Missouri, however, are clearly shown. The Illinois increases the nutrient concentration substantially while the Missouri accomplishes the opposite effect. The true magnitude of the effect of these two rivers may not be accurately represented at stations 16-19 due to incomplete mixing of these large tributaries with the Mississippi.

In segments with no large dischargers there is apparently a gradual withdrawal of nutrients in their most available form ( $\text{PO}_4$  and  $\text{NO}_3$ ) from the river, but this process is evidently unable to keep pace with the large point source nutrient additions to the Mississippi, for the overall trend is one of increasing concentration of nutrients in the downstream direction.

#### IV. Dissolved Oxygen

In small turbulent streams the oxygen content is usually at or above saturation, but

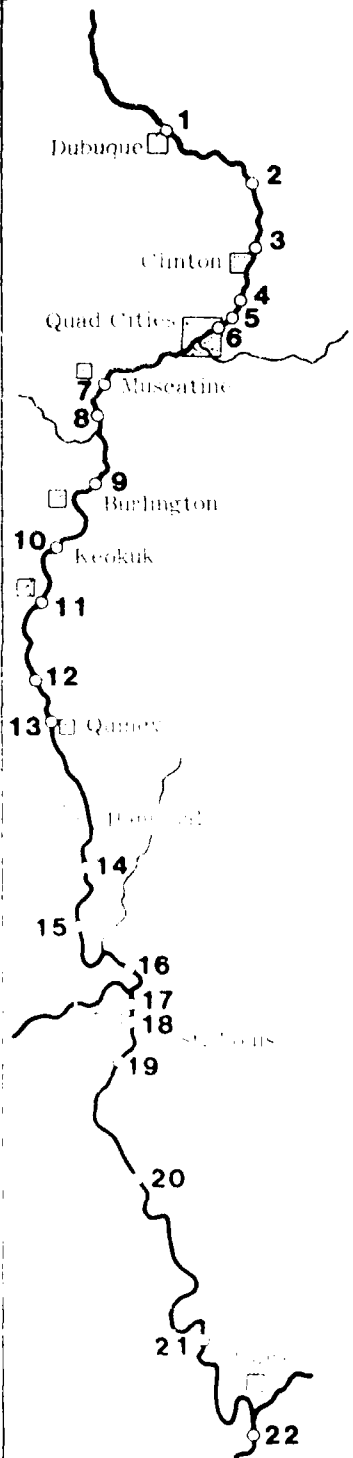
in more sluggish waters there is usually a greater range of dissolved oxygen (DO) saturation and lower values can occur. Larger rivers show similar trends but exhibit greater variation in dissolved oxygen values (Hynes 1970). High flows on the middle Mississippi have been shown to reduce dissolved oxygen because of the wash-in of organic matter and the reduction in photosynthesis caused by increased turbidity (Dorris, et al 1963).

Characterization of dissolved oxygen dynamics in the river has been complicated by the construction of navigation dams, which have exaggerated the original pool-chute nature of the Mississippi. Measurements made in 1930 showed 20 percent more DO above the Keokuk Pool than in it. Thirty miles below the dam, DO was 10-15 percent less than above the pool (Barnicol and Starrett, 1951). The Des Moines River may have contributed to the lower DOs below the dam, but no DO measurements were given for that river. Barnicol also stated that in 1944, Plattner reported a bi-modal oxygen sag with the first depletion immediately below St. Louis followed by a second sag below Crystal City.

Figure 4 gives information collected by the USGS on dissolved oxygen in the Mississippi at Canton, Missouri. The upper graph plots DO against time of day for rising versus stable hydrographs. Time of day was recorded only on the 1975 water year samples, so that even though there appears to be part of a diurnal DO pulse indicated, there are probably too few samples to justify this conclusion. The lower graph at first glance appears to be a scattergram showing no significant trends of DO variation with discharge or season of the year. A closer look, however, indicates the following:

1. DO saturation values are almost equally distributed between 55 and 90 percent, with very few values occurring outside of this range.
2. Without regard to season, during times of increasing discharge, DO concentration is less than at times of stabilized or decreasing discharge. The average of all data points on the graph are 70 versus 74.2 percent. This difference was significant at the 95 percent confidence level using a 1-tailed "t" test.

Table 1  
MEAN NUTRIENT CONCENTRATIONS MISSISSIPPI R.

	River Mile	Sta. No.	NO <sub>3</sub> -N (mg/l)	NH <sub>4</sub> -N (mg/l)	PO <sub>4</sub> -P (mg/l)
1	579	1*	0.54	0.12	0.17
2	537	2	0.66	0.09	0.20
3	520	3	0.62	0.11	0.20
4	512	USGS**	0.58	0.16	0.17***
5	503	4	0.93		0.23
6	496	5	0.74		0.19
7	485	6	0.76		0.21
8	455.5	7	0.99	0.24	0.21
9	437	8	1.44		0.31
10	410.5	9	1.44	0.22	0.30
11	384	10	1.37	0.21	0.28
12	364	11	1.56	0.22	0.30
13	364	USGS	1.29	0.11	0.24***
14	343	12	2.72		
15	327	13	1.36	0.20	0.26
16	283	14	1.94	0.20	0.30
17	241	15	1.59	0.19	0.25
18	204	16	2.65	0.25	0.25
19	203	USGS	2.13	0.21	0.28***
20	192	17	2.23	0.28	0.35
21	184	18	0.98	0.18	0.49
22	170	19	1.61	0.22	0.36
23	140	20	1.71	0.23	0.37
24	55	21	1.39		
25	37	USGS	1.65	0.15	0.32***
26	1	22	1.31	0.24	0.33

\* Numbered Stations are Illinois EPA Stations

\*\* USGS Sampling Station

\*\*\* Total Phosphorus

Figure 2  
CONCENTRATION OF NUTRIENT IONS  
IN THE UPPER MISSISSIPPI RIVER

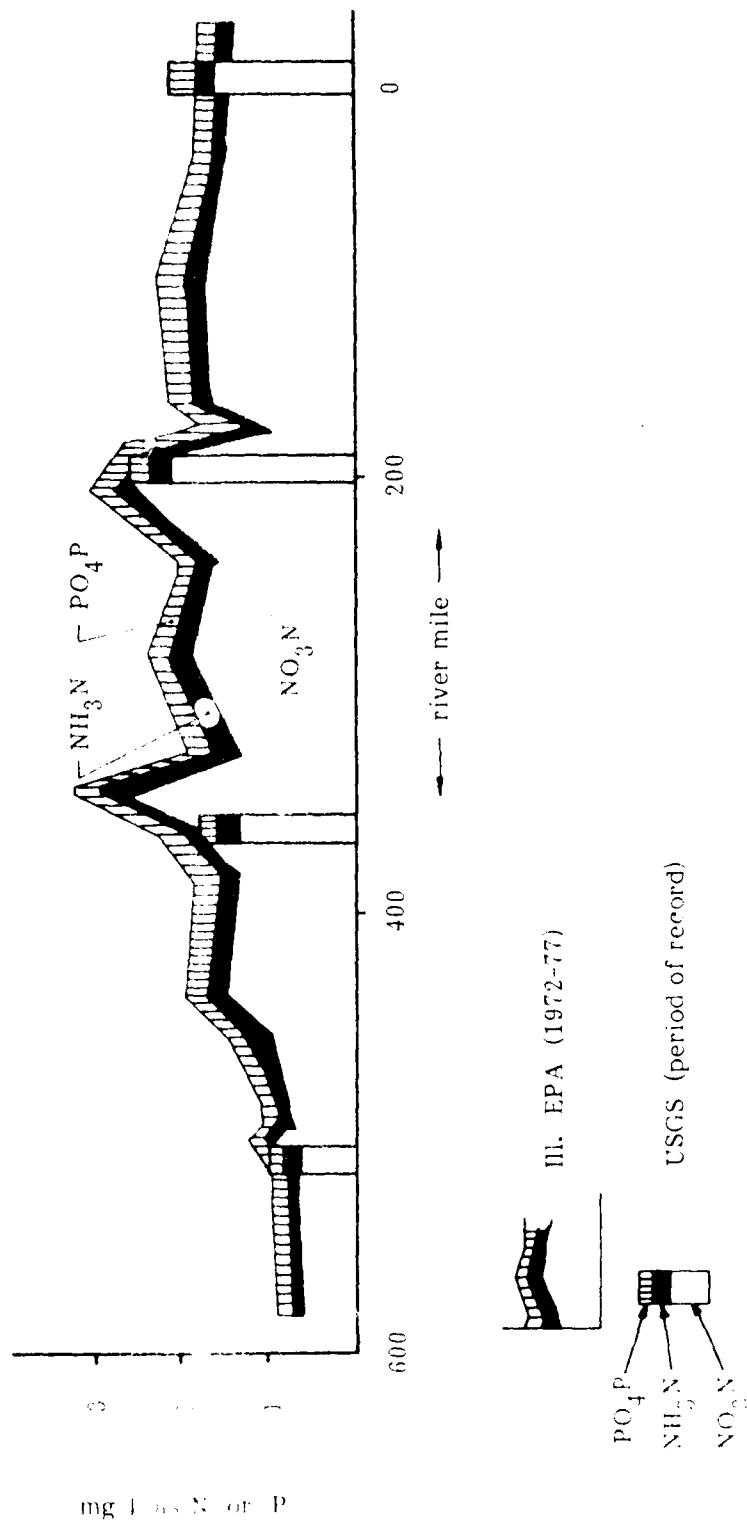
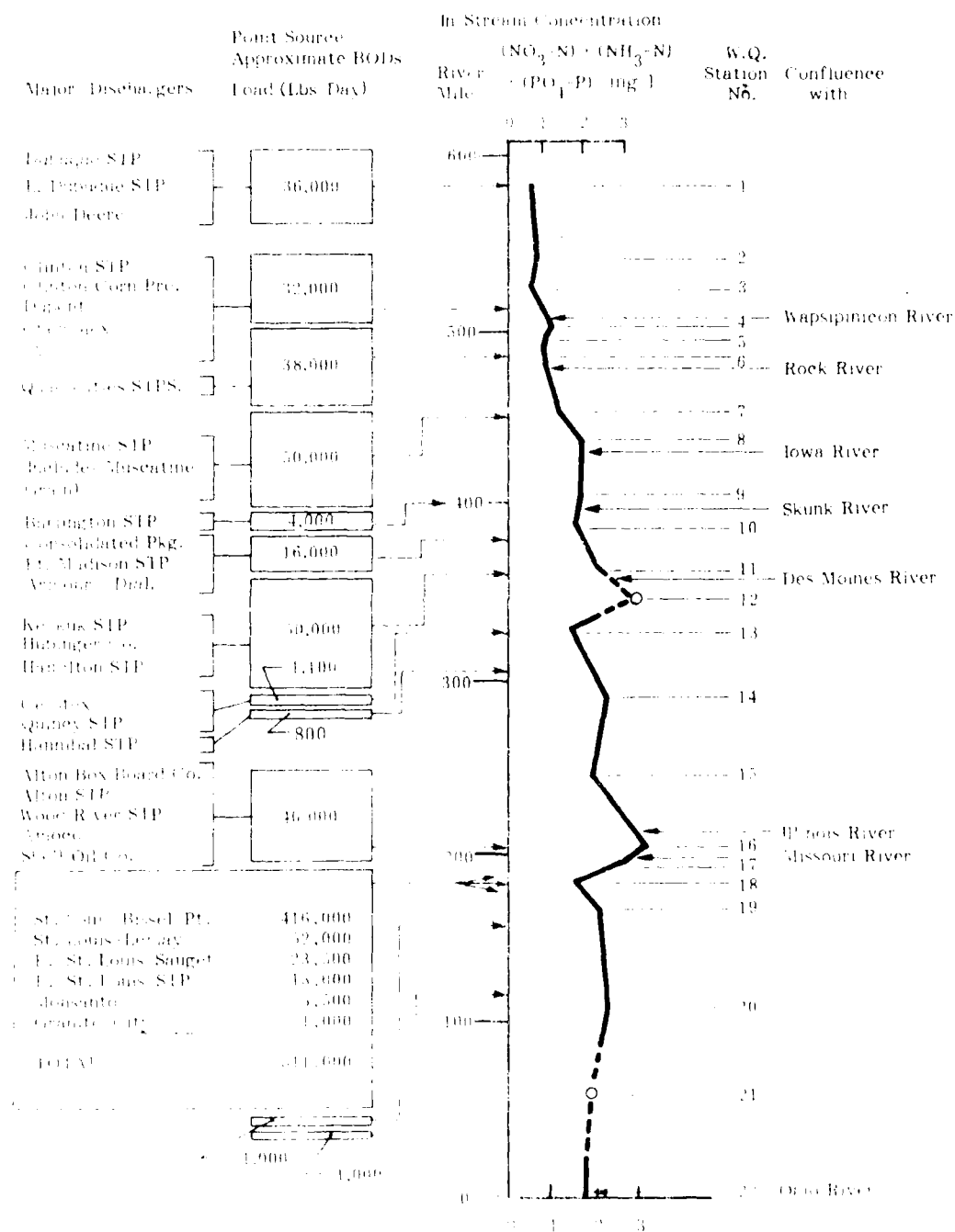


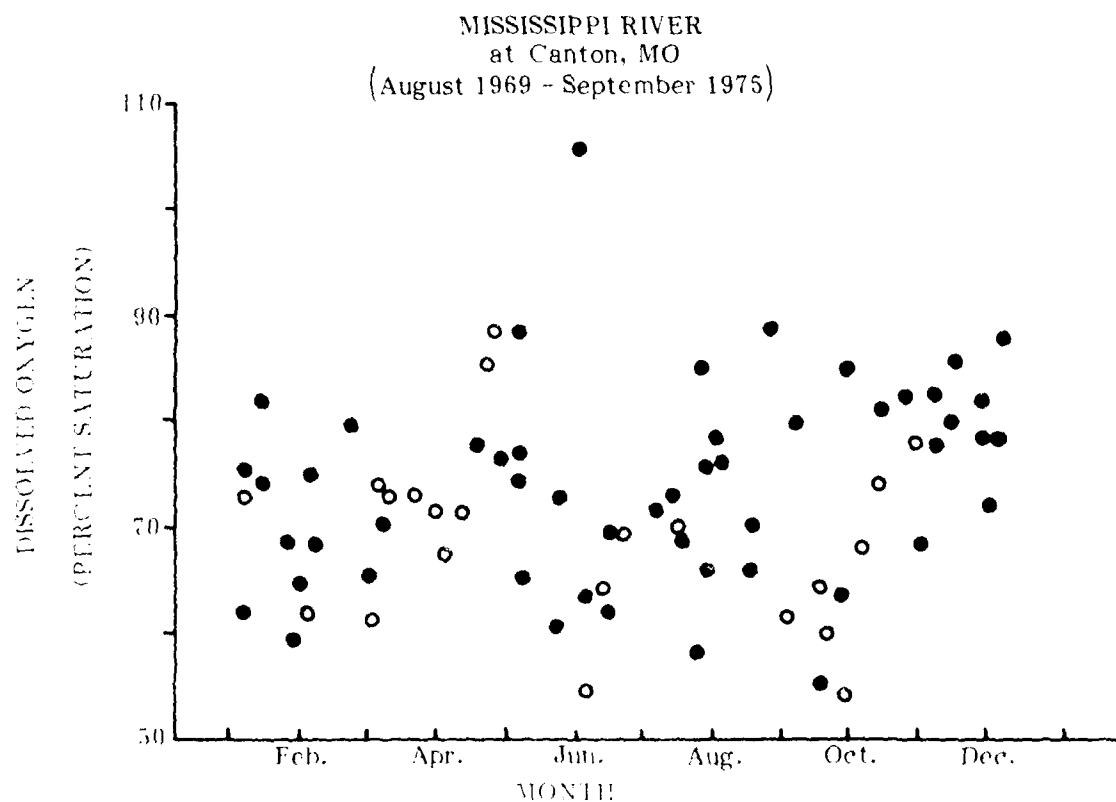
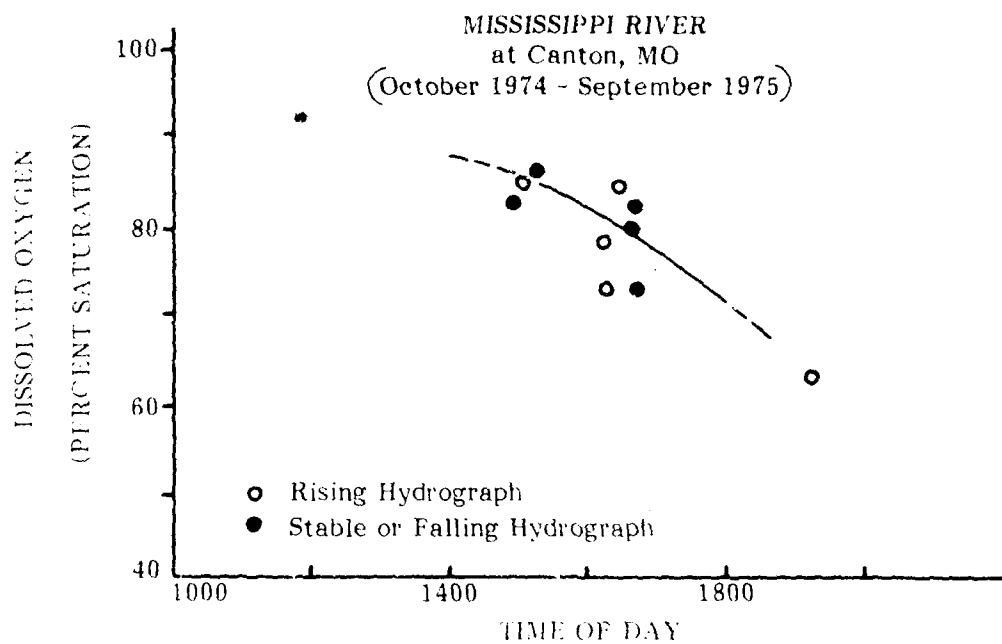
Figure 3  
Approximate BOD<sub>5</sub> Loading  
to the Upper Mississippi River



\* Data for stations 1 through 21 are from the Illinois River Water Quality Study, Illinois State Board of Planning and Development, 1970.

---○--- Nitrate-N concentration, mg/l (NH<sub>4</sub>-N)

Figure 4  
Dissolved Oxygen in Relation to  
Time of Day/Year



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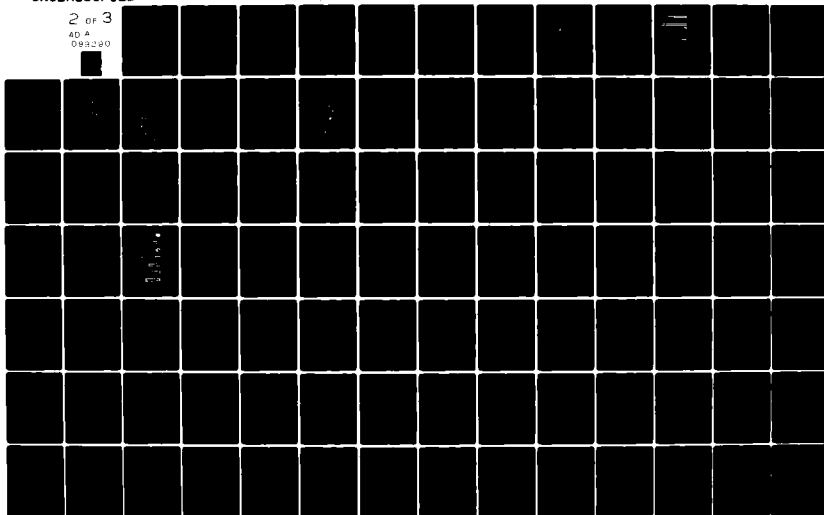
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3. A seasonal DO trend for rising hydrographs is evident. DO saturation values are lower in the summer and fall than in winter or spring, a trend which is consistent with the idea that the wash-in of oxygen-demanding material reduces DO during, and for some time after, rising hydrographs. Between November and May, ten of thirteen DO values on rising hydrographs were above 70 percent saturation, but between May and November, only one of eleven values measured was above 70 percent.
4. A less distinct trend is discernible for stable or falling hydrographs. A very noticeable rise occurs from late summer into December, followed by a sharp reduction in percent saturation from January through March. Figure 5, by giving the monthly average DO in milligrams per liter, shows that seasonal DO and temperature trends are very similar except during this January to March period. Presumably, ice cover above Lock and Dam #20 is reducing atmospheric oxygen assimilation rates.

While this discussion has centered around DO variations at one point on the river through time, there are important spatial DO variations that occur at any one time. The exact nature of these variations is largely unknown due to the limited number of places that DO has been concurrently determined on the river.

Typical sources of spatial variation would include the DO sag and recovery curve from point sources (only large sources might cause a demonstratable DO sag), the difference between lentic and lotic sections of the river, and horizontal and vertical DO variation within pools caused by thermal stratification, primary production, respiration and the residence time of water in various parts of the pool.

The Illinois EPA has been sampling the Mississippi for dissolved oxygen at various locations, and average DO values based upon 20 to 100 samples per location are given in Figure 6. The accuracy of some of the data is questionable since individual samples showed values as high as 30 mg/l and others as low as 0 mg/l. USGS data from Canton

(Figure 2) showed that recorded DO values were never below 50 percent of saturation, even during higher summer temperatures (28°C); this 50 percent saturation would result in DO concentrations of about 3.8 mg/l. While individual values may be in error, the plot of average DO values in Figure 6 does compare favorably with USGS data in Figure 5. Both sets of data show average DO values for the Mississippi near Canton to be between 8 and 9 mg/l.

The data plotted in Figure 6 affords some indication of spatial DO trends in the Upper Mississippi River. The most wide-ranging trend is the slight decline in average annual DO concentration in the downstream direction. Linear regression of these data points show a line slope of 0.523 mg/l per 100 river miles, or a difference of 3.14 mg/l in the average DO content between Guttenburg, Iowa and Cairo, Illinois. Using this information and a table of oxygen saturation values one finds that it would require a water temperature difference between the two cities of 9.5°C in the winter and 24°C in the summer for solubility to account for this difference in average DO. Temperature differences of this magnitude are rarely realized. Typically, temperature differences between these cities are not greater than 5 or 6°C. If the average DO data presented in Figure 4 accurately portray this general trend, then an increasing dissolved oxygen demand is being placed on the river as it moves downstream.

Less extensive but more interesting DO variations include apparent sags below Clinton and Keokuk, Iowa and lowered DO values in the Alton Pool. The magnitude of the apparent sag and the close group of four stations within a 35-mile stretch of the river, made the segment from Clinton to Davenport, Iowa, the best place to examine the DO response of the Mississippi to point source pollution. As Figure 3 indicates, the major dischargers in the Clinton Area place approximately 32,000 lbs./day BOD<sub>5</sub> into the river between river miles 514 and 509.

On nineteen occasions, DO samples at these four stations were taken on the same or adjacent days. The three stations immediately below Clinton were always sampled on the same day. The changes in DO from

Figure 5  
MONTHLY AVERAGE TEMPERATURE  
AND DISSOLVED OXYGEN, MISSISSIPPI RIVER  
at Canton, MO  
(August 1969 - September 1975)

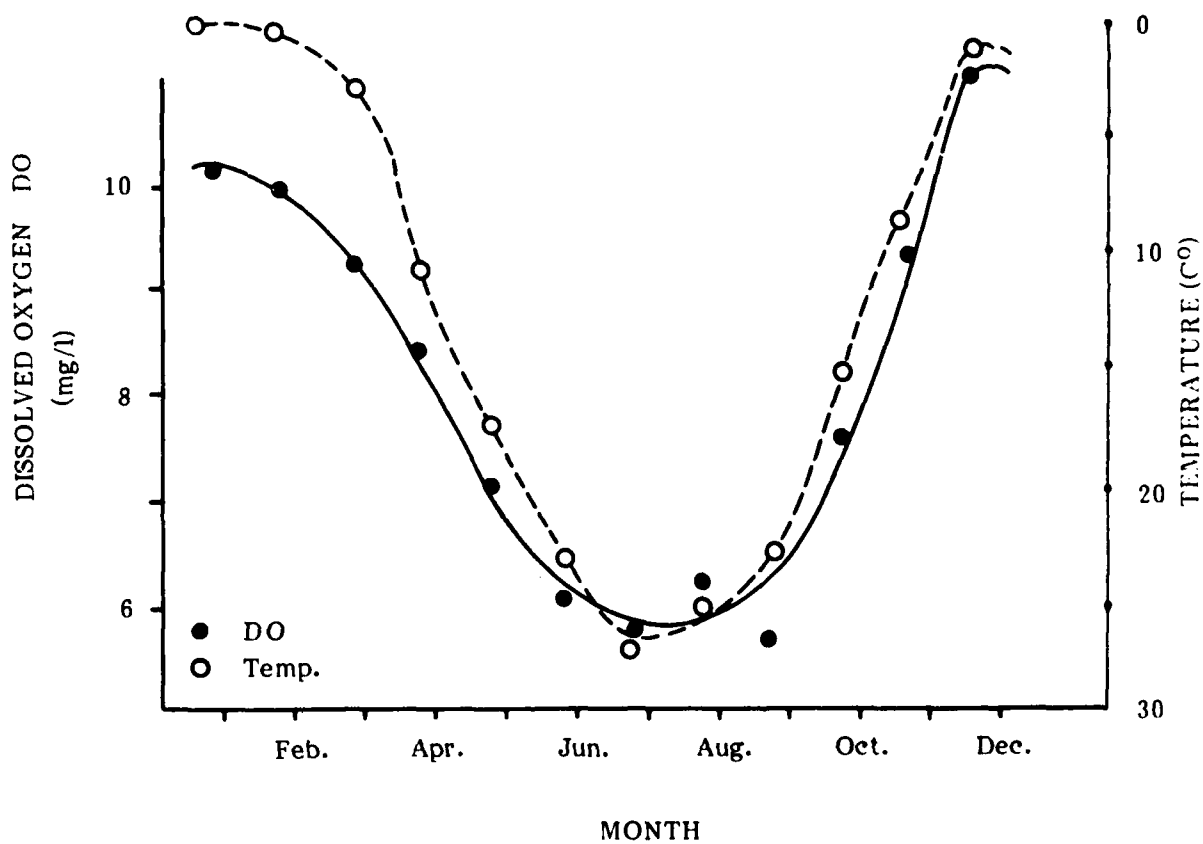
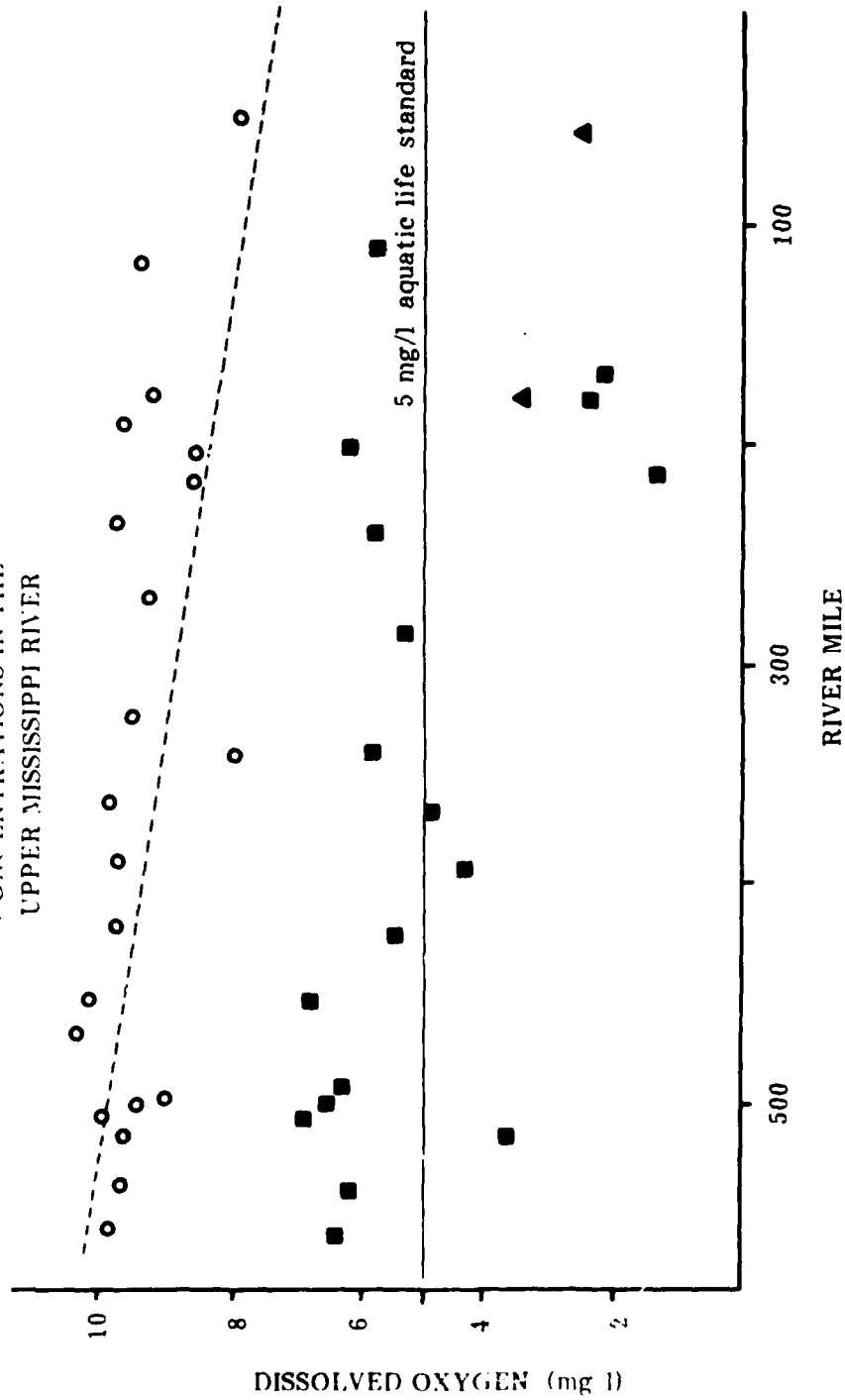


Figure 6

MEAN AND MINIMUM DISSOLVED OXYGEN  
CONCENTRATIONS IN THE  
UPPER MISSISSIPPI RIVER



- Mean Dissolved Oxygen Concentration: Period of Record, Ill. EPA
- Minimum Dissolved Oxygen Concentration: Ill. EPA (1975-1977)
- ▲ Minimum Dissolved Oxygen Concentration: USGS

station 4 to station 5 and station 5 to station 6 were examined statistically, using the Wilcoxon test.\* The change in DO from stations 4 to 5 or from stations 5 to 6 was not significant at the 95 percent confidence level. The sample was disaggregated into the periods June through mid-October and mid-October through May. Average DO values for these two periods graphed in Figure 7, show opposite DO trends, with a slight oxygen sag at station 5 during the summer but a displacement and weakening of any sag further downstream during the cooler months. Figure 7 demonstrates the weakness of using average annual DO data to characterize DO trends in this segment of the river. Statistical tests, however, showed the differences in average DO between stations during the warm weather or the cooler weather period were not significant at the 95 percent confidence level. The disaggregation, however, lowers the degree of freedom in the test and makes it less sensitive to real variation. Thus, the existing data may suggest that discharges in the Clinton area cause an oxygen sag in the Mississippi, but statistically a high degree of reliance cannot be placed on that assumption.

The spread of sampling stations below other cities is too great to define any oxygen sag on other sections of the river.

Minimum DO values are another important facet of DO variation. Average DO values are meaningless to aquatic organisms if DO minima are below their range of tolerance. The minima plotted in Figure 4 are from

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\*DO values at Canton were evaluated by the use of the parametric "t" test, an acceptable test for a variable with normal distribution and a mean of zero. Since the variable for evaluating the difference in DO values between stations is expressed as  $X = (\text{DO in mg/l at Sta. X}) - (\text{DO in mg/l at Sta. Y})$ , differences in mean annual temperature, opportunities for reaeration and the presence of Lock and Dam #14 may cause differences in average DO at the various stations. The variable may have a normal distribution but probably does not have a mean of zero. Therefore, the nonparametric Wilcoxon test is used.

Illinois EPA data collected from 1975 through 1977, and from USGS for various dates. These data indicate the lowest DO values occur in the Alton Pool and in the Mississippi at St. Louis (locations which correspond to the greatest amount of BOD loading in the GREAT II-III segment) and in the Cape Girardeau area. Since the stations immediately above the St. Louis and Alton areas do not have low DO minima, this suggests that a large amount of short-term BOD and/or COD is entering in the Alton-St. Louis area. Low DOs in Cape Girardeau would indicate longer term BOD or COD from the St. Louis-Alton area.

A concentration of at least 5 mg/l DO is generally accepted as necessary for maintaining a diverse aquatic fauna. It must be noted, however, that the higher metabolic rates of aquatic animals during warmer temperatures require more oxygen, so that a 5.0 mg/l standard does not provide the same level of protection in all seasons. Numerous studies have addressed the dissolved oxygen of requirements of various fish species. The following summary is taken from California Water Quality Criteria (McKee and Wolf, 1963).

"The lethal effect of low concentrations of dissolved oxygen appears to be increased by the presence of toxic substances, such as excessive dissolved carbon dioxide, ammonia, cyanides, zinc, lead, copper, or cresols. With so many factors influencing the effect of oxygen deficiency, it is difficult to estimate the minimum safe concentration at which fish will be unharmed under natural conditions

"Extensive studies have been made by Moore in which fish of several species were confined in boxes of wire netting and lowered to varying depths in lakes. The concentration of dissolved oxygen

and the temperature were noted at each depth, and the reactions of the fish were observed. His results show that the median fish will die at concentrations of 3.1 mg/l in summer and 1.4 mg/l in winter, and will live at 4.2 mg/l in summer and 3.1 mg/l in winter.

"In a somewhat similar study, the Water Pollution Research Board of England found the minimum oxygen tensions at which various fish would survive 84 hours at 16° C ranged from 3 mg/l for Rainbow Trout (*Salmo gairdneri*) to 0.54 mg/l for the Tench (*Tinca tinca*).

"Ellis indicated that under average stream conditions, 3.0 mg/l of dissolved oxygen, or less, should be regarded as hazardous or lethal, and that to maintain a varied fish fauna in good condition the dissolved oxygen concentration should remain at 5.0 mg/l or higher."

DO measurements in the water column may not reflect DO conditions near the bottom of pools within the river. Dissolved oxygen concentrations near the bottom muds of sluggish rivers may approach zero. Under such conditions, the hatching of fish eggs has been delayed, or the fish hatching from such eggs have been deformed (McKee and Wolf, 1963).

If the data on minimum DO values reported here for the Mississippi are accurate, there are segments of the river periodically unsuitable as fish habitat due to low DO concentrations.

#### V. Thermal Discharges

Current velocity and temperature are considered by most steam limnologists to be the

two variables which exert the greatest influence upon the character of running waters. Although temperature affects such physical aspects of water as density, viscosity and gas solubility, its greatest effects are in determining the composition and regulating the seasonal cycles of aquatic biota.

Temperatures determine distribution patterns of entire populations and also whether a specific individual organism can survive in a particular location. In the latter instance, the effects of discrete thermal discharges become of concern. The largest thermal discharges on the Upper Mississippi are cooling water return flows from large power plants. As part of the National Pollutant Discharge Elimination System (NPDES) permit process, these facilities submit quarterly reports on the thermal changes made in the river as a result of their discharge. Data from thermal monitoring reports for several large power plants are summarized in Table 3 and their locations are shown in Figure 8.

As Table 3 shows, the large size of the Mississippi usually mitigates thermal impacts quickly from even large power plants. Cooling water withdrawals are typically less than 1 to 2 percent of river flow. The shapes of the thermal plumes vary greatly between locations but the area of water greater than 5° F above ambient temperature typically represents no more than 1 to 6 percent of the river cross-section. However, since mixing zones for thermal discharges are typically in the faster flowing part of the river cross-section, the percent of the river passing through the heated plume is greater than the percent of cross-sectional area represented by the plume. In the case of Union Electric's Rush Island Plant, the percent of river passing through the cross-section is greater by a factor of at least 4.

The length of the plume can be substantial. The 5° F over ambient temperature plume has been found a mile and a third in length below the Iowa-Illinois Gas and Electric Plant in Davenport, and plume lengths almost a mile long have been found at Portage Des Sioux, the Union Electric plant above St. Louis. The most interesting feature of the Sioux plant thermal plume is the great change in its shape with changes in river discharge. The extent of the 5° F over ambient thermal

Figure 7

AVERAGE DISSOLVED OXYGEN CONCENTRATIONS  
FOR THE MISSISSIPPI RIVER BELOW CLINTON, IOWA

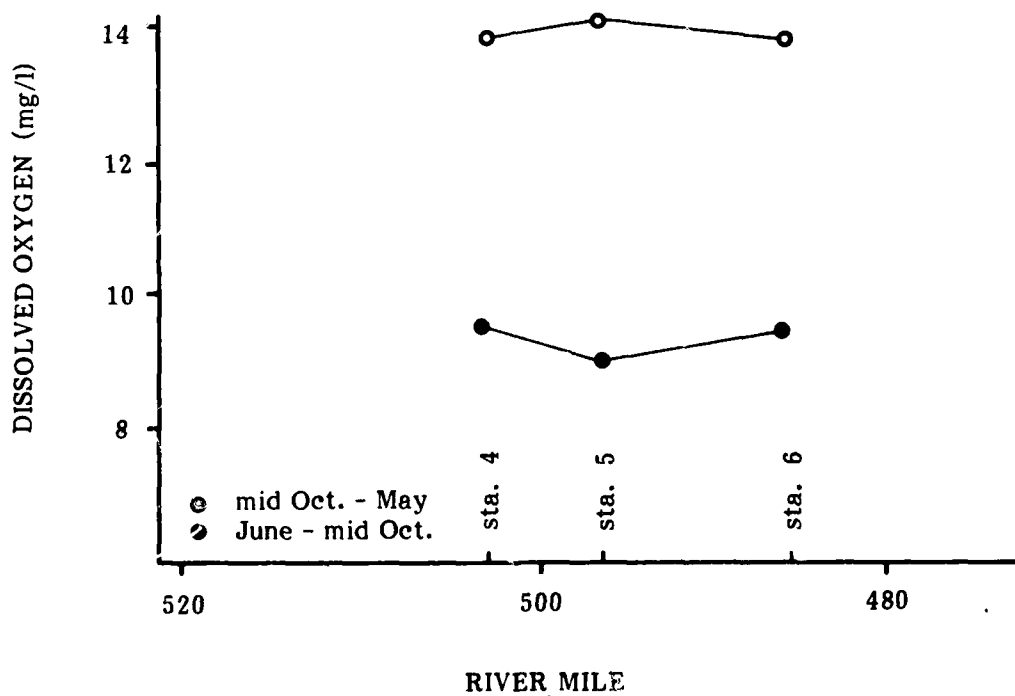


Table 3  
SUMMARY OF THERMAL MONITORING DATA FOR SELECTED POWER PLANTS ON MISSISSIPPI RIVER

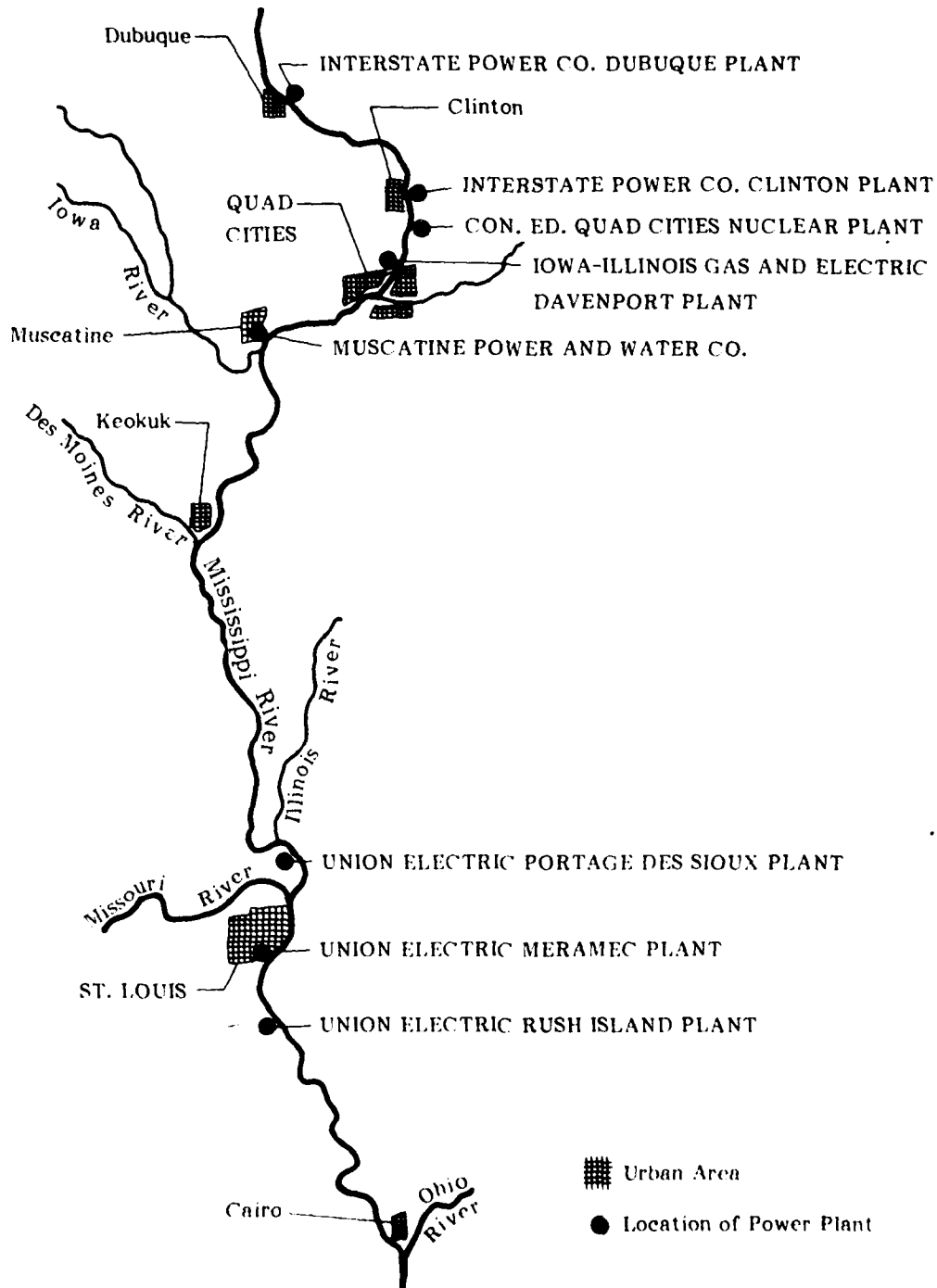
NAME	LOCATION	PERCENT OF RIVER USED AS COOLING WATER	LENGTH	WIDTH	MAXIMUM EXTENT OF +5° F ISOTHERM	
					SURFACE AREA (acres)	PERCENT OF RIVER PASSING THRU CROSS-SECTION
Interstate Power Co.*	Dubuque, IA	0.15-1.2	150-450'			1.3-6.7
Interstate Power Co.*	Clinton, IA	1.6-5.9 of Beaver Channel	500-600'			8.7-14.2 of Beaver Channel
Commonwealth** Edison	Cordova, IL main diffuser pipe intake forebay		70' 500'	800' 150'		
Iowa-Illinois* Gas & Electric	Davenport, IA	0.4-2.6	379' to 7,181'	19-132	0.1-17	
Muscatine Power & Water Co.*	Muscatine, IA	1	1300-1500	40		1
Union Electric Co.***	Portage Des Sioux, MO	0.6-3.8	1040-4600'		7-92	1.5-5.3
Union Electric Co.***	St. Louis, MO	0.4-1.2	270'-490'		0.7-1.5	4.5-5.7
Union Electric Co.***	Rush Tower,	0.8-2.2	50-230'		0.1-0.3	1%
						3.5-4.1

\*Personal communication, U.S. EPA, Region V, Chicago, Illinois

\*\*Personal communication, U.S. EPA, Region VII, Kansas City, Missouri

\*\*\*Files, Missouri Department of Natural Resources, Jefferson City, Missouri

Figure 8  
LOCATION OF LARGE POWER PLANTS IN THE  
GREAT II-III SEGMENT OF THE UPPER  
MISSISSIPPI RIVER



plume on the surface of the Mississippi below the Sioux plant was once estimated at 92 acres.

The major problems associated with these thermal mixing zones (areas greater than 5 °F over ambient temperature) are the heat shock they can place on fish and ichthyoplankton (larval fish and fish eggs). Ichthyoplankton drift with the river current and are therefore affected to a degree proportional to the percent of river passing through the mixing zone. Based upon figures in Table 3, 10-20 percent of the river at times may flow through a mixing zone. Once fish reach the swimming stage, they can choose to avoid or be drawn to heated discharges. Avoidance of areas of heated waters reduces potential fish habitat and can interfere with fish movement. Attraction to heated waters is common in winter, and during this time of year areas of heated waters often provide better habitat than other areas of the river. Fish mortality occurs, however, when fish acclimated to colder waters move too quickly into heated waters. The opposite phenomenon, fish acclimated to heated waters killed due to the shock of colder waters, occurs during the winter when a power plant shuts down or greatly cuts power generation.

Although we are aware of these effects on fish, we do not know the magnitude of the impact on the total fisheries resource of the river. Knowledge of the numbers of fish and the age class distribution of various species is difficult to obtain on a river the size of the Upper Mississippi. Until we have this knowledge, the impact of a power plant, or several power plants on the fisheries resource, will not be known.

## VI. Fecal Coliform

Coliform bacteria are commonly associated with the gastrointestinal tracts of warm-blooded animals, and laboratory tests for their presence and concentration are relatively easy. This test is commonly used as an indicator of the bacteriological health hazard presented by the water. Results of total coliform tests must be tempered by the realization that many soil bacteria are of the coliform group. Tests for fecal coliform are assumed to truly identify bacteria from the intestinal tract of warm-blooded animals.

Therefore, sewage treatment plant effluent may have high concentrations of fecal coliforms. Even fecal coliform however, do not present a clear picture of the microbiological hazards to health. Several non-fecal bacteria can cause infections of eye, ear, nose and throat, and many diseases can be caused by waterborne viruses.

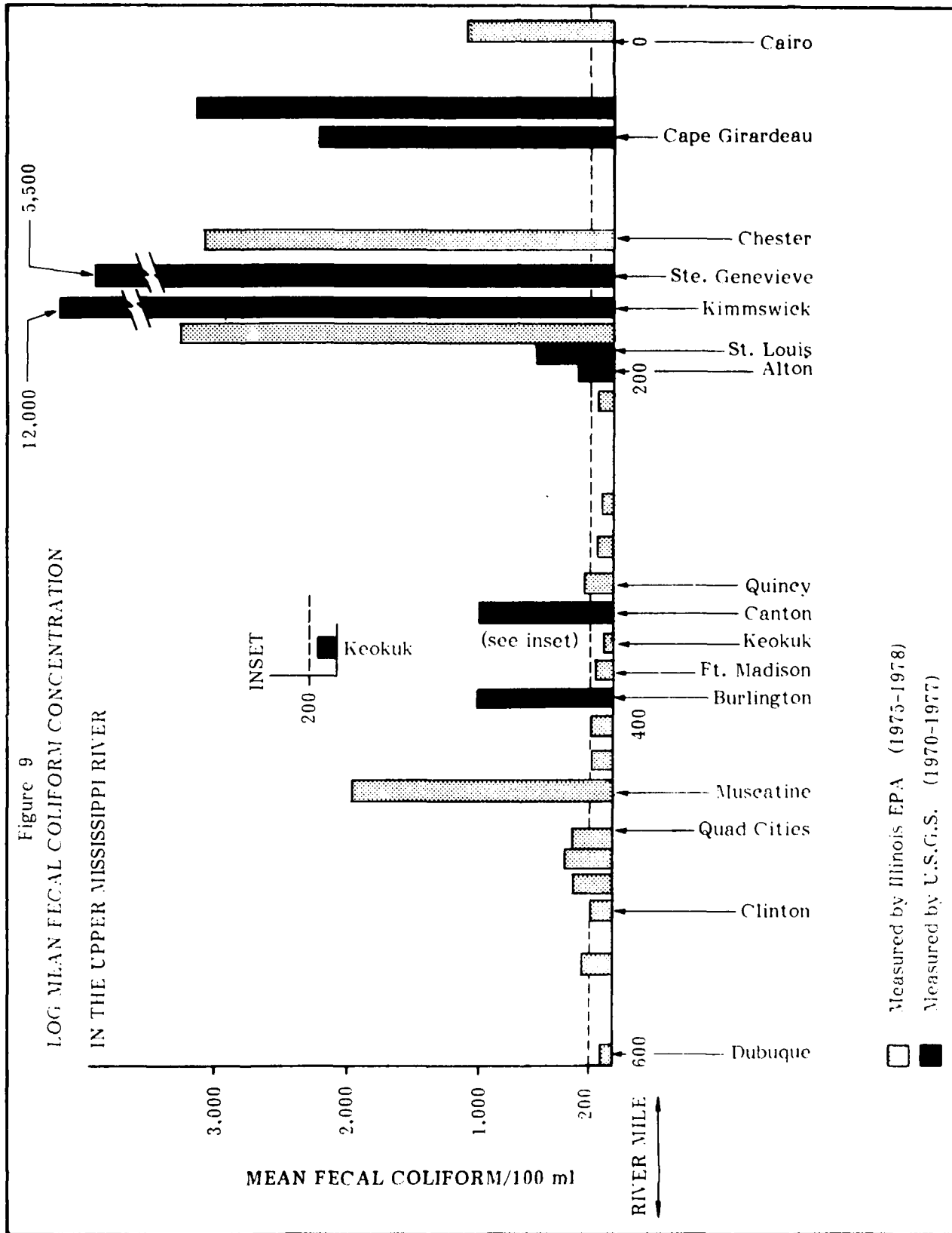
The average fecal coliform concentrations per 100 ml based on the log mean are shown in Figure 9 for 25 locations on the Upper Mississippi. The Illinois EPA data were gathered between January 1975 and January 1978, and USGS data are from water year 1970 to 1977.

The plot of average fecal coliform concentrations\* shows important spatial variations. Most sampling stations were on bridges in urban areas, so that if upstream contamination sources were present, high coliform counts were found (Muscatine and Burlington, Iowa, Canton, Missouri, and at all locations below St. Louis). In other cities (Dubuque, Clinton, Ft. Madison and Keokuk, Iowa and the Quad Cities), there were no large sources of fecal coliform immediately above the sampling sites, and counts were low. Based upon the data presented, the most important conclusions to be made are; first, above St. Louis (except where influenced by local sources) fecal coliform levels in the Mississippi are generally near the 200 per 100 ml standard. Secondly, average fecal coliform concentrations below local sources can greatly exceed the recommended standard. Thirdly, the St. Louis area is responsible for a high level of bacterial contamination. The elevated levels of fecal coliform apparently persist throughout the remaining downstream segment of the Upper Mississippi. Since the State of Illinois has designated all the Mississippi for general use, which includes whole body contact recreation, the fecal coliform standard is consistently violated below St. Louis.

Population differences alone do not explain the order of magnitude increase in average

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\*Average fecal coliform concentration was determined by averaging the logs of all fecal coliform measurements and finding the anti-log of that value.



fecal coliform below St. Louis. Major urban areas from Dubuque to Keokuk have just over 400,000 population, while St. Louis and downstream communities have somewhat less than twice that number of people (1970 census). Chlorination policies of the three states involved better explain the variations in average fecal coliform density shown in Figure 9. Major discharges of domestic sewage to the Mississippi in Iowa chlorinate wastewaters during the recreational season (April 1-October 31), while Illinois typically has chlorination on newer plants and no chlorination on older ones. Missouri does not chlorinate sewage treatment plant effluent.

## VII. Toxic Compounds

### A. PCBs

PCBs are a group of man-made organic compounds which may vary in state from liquid to crystal, but which all exhibit great stability under pressure and over a wide range of temperatures. Consequently they have found wide use in industry. The compounds consist of two joined phenol groups with one or more chlorine atoms replacing hydrogen atoms on the outside of the phenol rings. Mono- and dichlorobiphenyls (which have only one and two chlorine atoms respectively) are readily biodegradable, but PCBs with three or more chlorine groups become increasingly toxic and therefore more difficult for bacteria to metabolize.

PCBs are toxic to humans. PCBs have caused skin disease and abnormal pigmentation in over 1,000 people in Japan, and experiments with Rhesus monkeys showed skin disease and reproductive system dysfunction (including abortion and stillbirth) occurred at levels as low as 2.5 mg/kg PCBs in their diets (Hora, 1976).

PCBs are found virtually everywhere. An important method of transport is evaporation and movement in the atmosphere (Mackay 1973, Harvey 1976). Surface runoff, subsurface seepage and spills from areas of manufacture, use and disposal contribute to PCB pollution of waters.

Ingestion of PCBs via contaminated water supplies, however, does not appear to be a problem. PCBs have very low solubility in water and appear to be present primarily by adsorption to suspended sediment. Studies of PCB removal by municipal and industrial waste treatment plants in Wisconsin showed high levels of PCB removal. Municipal plants have shown 70 percent or better reduction in PCBs, and some industries have had even greater levels of reduction in PCBs after treatment (Kleinert, 1976). The primary method of PCB reduction in both cases is precipitation of suspended solids, but some bacterial decomposition is probably involved. Since public water suppliers drawing from surface waters routinely use some type of coagulation and clarification process, PCBs in water supplies do not appear to be a problem. No PCB poisoning is known from concentrations existing in the waters of the Upper Mississippi Basin. While PCBs are not water soluble, they are fat soluble, and, like chlorinated hydrocarbon insecticides, can accumulate in animal tissue many thousands of times their concentration in the water. This fact was drawn to public attention in 1970 when carp caught by commercial fishermen in Lake Pepin, a large natural pool in the Mississippi River, were denied interstate shipment because fish contained more than the FDA-allowed, 5 mg/kg maximum PCB concentration. The mechanism of uptake is debatable. Some feel uptake follows the food chain and contamination results primarily from ingestion of food. Others believe assimilation directly from the water is the most important source. Study of PCB data in the Upper Mississippi has led the U.S. Fish and Wildlife Service (1975) to conclude that regardless of mechanisms, the incidence of fish contamination correlates strongly with PCB concentrations in the water.

Since 1970 a number of studies have attempted to assess the extent of the contamination of fish by PCBs. Much of the data gathered during these studies is presented in Table 4. Essentially, these studies showed that virtually all fish downstream of major urban areas contained PCBs. Lakes and impounded sections of rivers which allowed suspended materials

Table 4

LEVELS OF PCBs IN THE TISSUE OF FISH  
FROM SEVERAL LOCATIONS ON THE UPPER MISSISSIPPI RIVER (mg/kg)\*\*\*

LOCATION	ROUGH FISH*			GAME FISH**		
	1970	1973-4	1975-7	1970	1973-4	1975-7
Sartell, MN			0.19			
Monticello, MN			1.18			.19
below Coon Rapids, MN			0.55			.26
St. Anthony Falls, MN			4.30			.49
below L & D #1			5.58			1.83
Spring Lake, MN			6.53			1.60
Prescott, WI	16.86	7.22	3.18	41.18	6.22	3.18
Lake Pepin @ Bay City	8.92		1.65	21.93		
@ Maiden Rock			2.52, 0.73			0.94, 1.03
@ Pepin	13.26	6.81	4.07, 1.70, 7.80	32.73	12.32	1.11, 1.13
Nelson, WI	19.01	6.93	3.35, 3.34	8.08	5.19	0.25, 0.40
Alma, WI	9.25	6.63	2.98	11.04	9.08	0.40
Fountain City, WI	2.68			5.90		
Trempealeau, L & D #6	7.74		2.40	4.58		
@ Trempealeau River	3.54	3.43		2.86		
La Crosse, WI	3.30	2.82	2.60	1.19	2.54	0.36
Stoddard, WI	1.99			1.21		
Genoa, WI	2.53		3.75	2.25		
Lansing, IA			2.80			0.22
Ferryville, WI	1.28			1.06		
Lynxville, IA	3.14		1.32	2.24		0.34
Prairie Du Chien, WI	3.67			1.93		
above Wisconsin R.	1.69			1.33		
below Wisconsin R.	2.09			0.68		
Cassville, WI	2.13		1.01	0.91		0.12
Dubuque, IA	1.65		0.22	1.25		0.23
Clinton, IA			0.34			
Davenport, IA			0.46			0.10, 0.14
below Burlington, IA			0.14			
Warsaw, IL			0.43			
Meyer, IL			0.20			
Quincy, IL			0.47			
Hannibal, MO			0.96			
below St. Louis, MO			1.55			
Cape Girardeau, MO		2.5-1.0	0.86-3.2		0.80-1.20	0.20-0.27
Caruthersville, MO			1.30, 1.60			0.14

\*Catfish, Suckers, Shad, Carp

\*\*Pike, Walleye, Blackbass, Sunfish

\*\*\*Data taken from: Lorenz, 1976; Klemert, 1976; Hora, 1976; Skeffy, 1977;  
Iowa Conservation Comm., 1976; Missouri Dept. of Conservation, unpublished data.  
Environmental Science Laboratory, Columbia, Mo., unpublished data.

to settle out contained fish with particularly high levels of PCBs. The highest level in the basin have been found in the Mississippi River impoundments and pools immediately below Minneapolis-St. Paul down to and including Lake Pepin. During 1970, game fish samples from Lake Pepin contained an average of 32 mg/kg PCBs. In 1975, fish samples from this same area were lower but showed that many locations still have average fish contamination levels above the present FDA 2 mg/kg limit. Samples taken in 1976 by the U.S. EPA show that the problem is less severe in other parts of the Upper Mississippi River, but the urban areas of Davenport, Iowa and St. Louis, Missouri, are still significant contributors to PCB contamination in fish (Lorenz, 1976). Due to their persistence and affinity for sediments, PCBs will continue to contaminate fish and other aquatic life for many years. The cutbacks in the discharge of PCBs to the Mississippi is reflected by the reduction in PCB levels in fish flesh. Levels of PCBs in Lake Michigan have not shown this degree of reduction. This may be due partly to a continuing high level of PCB loading to the lake but also to the differences in sediment dynamics between a lake and a river. Researchers in Japan have shown that PCBs have a greater affinity for smaller particles (Choi, 1976). Therefore, the amount of PCBs flushed through and out of the Upper Mississippi could be a significant factor contributing to the reduction of PCB levels in fish in that river.

As Figure 10 shows, the Minneapolis-St. Paul area of the river still contains fish populations with PCB content two and three times greater than the FDA 2 mg/kg limit. The great difference in average fish tissue contamination levels in two nearby sections of the river in the Twin Cities area shows that the hydraulic characteristics and the mobility of sediments in a particular segment of the river are probably more important than distance from the source of PCB contamination. Therefore, although Figure 10 shows increasing levels of PCBs in fish from Dubuque to Clinton to the Quad Cities, it is not clear whether the trend is in response to additional PCB sources in this section of the

river or to the relative abilities of these areas to catch and retain PCB-contaminated sediments. Certainly additional PCB sources exist below the Twin Cities as indicated by fish tissue PCB levels of 0.04 to 0.19 mg/kg in the Iowa, Cedar and Des Moines Rivers.

In general, the trend is toward a reduction in PCB fish contamination in the Upper Mississippi over time (from 1970 to 1977) and over distance (from the Twin Cities to St. Louis). Below St. Louis there are substantial increases in PCB concentration in fish.

#### B. Pesticides

The occurrence of detectable levels of pesticides is widespread in the waters of the Upper Mississippi Basin. Figure 11 shows the location of pesticide sampling stations in the Upper Mississippi Basin for which USGS has published data. At many stations, pesticides have been found in concentrations exceeding their recommended levels. Although analyses for many pesticides have been conducted since 1972, including organophosphates such as Diazinon, and Chlorophenoxyacetic acids such as 2, 4-D; 2,4,5-T and Silvex herbicides, only the chlorinated hydrocarbons — the "hard pesticides" — were found in levels exceeding EPA's water quality standards.

Detectable levels of these chlorinated hydrocarbons are rarely found in the headwaters of the Mississippi, and this appears to be more a result of land use patterns than basin process. The headwaters are primarily northern coniferous forest areas of less intensive pesticide use. Further down in the basin, the streams drain the more intensely cultivated lands of southern Minnesota, Iowa, Missouri and Illinois where pesticides are used more frequently. This pattern of use is reflected in the greater pesticide occurrence in the waters of these areas. As stream order increases, however, dilution appears to play a more important role than recruitment of additional sources, since the number of chlorinated hydrocarbon pesticides detected in the main stem of the Mississippi is lower than that of many tributaries. Table 5

Figure 10  
CONCENTRATIONS OF PCBs IN FISH TISSUE  
1975-1977  
(mg/kg)

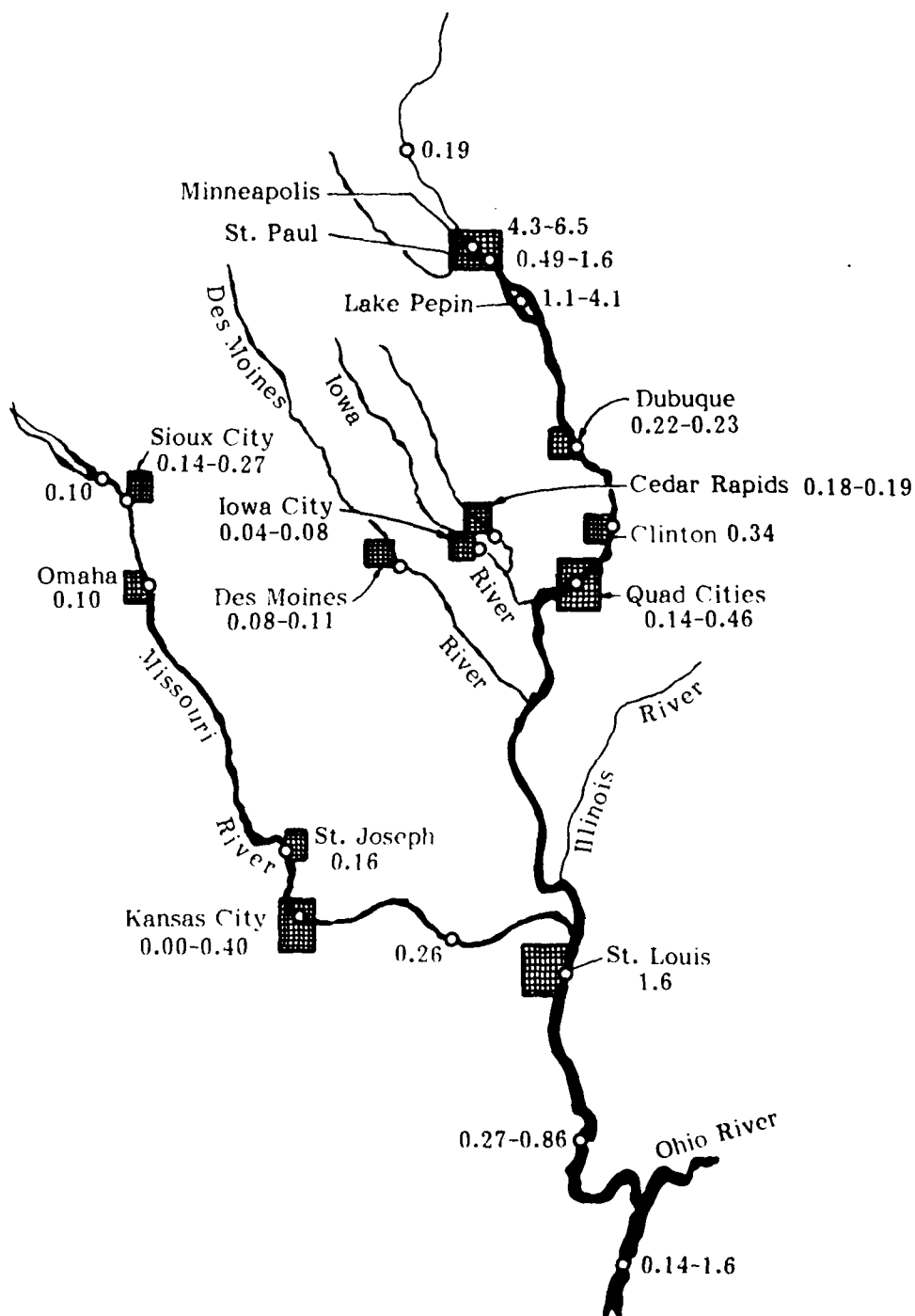


Figure 11  
THE OCCURRENCE OF PESTICIDES  
IN THE WATERS OF THE UPPER  
MISSISSIPPI RIVER BASIN  
(USGS 1972-76)

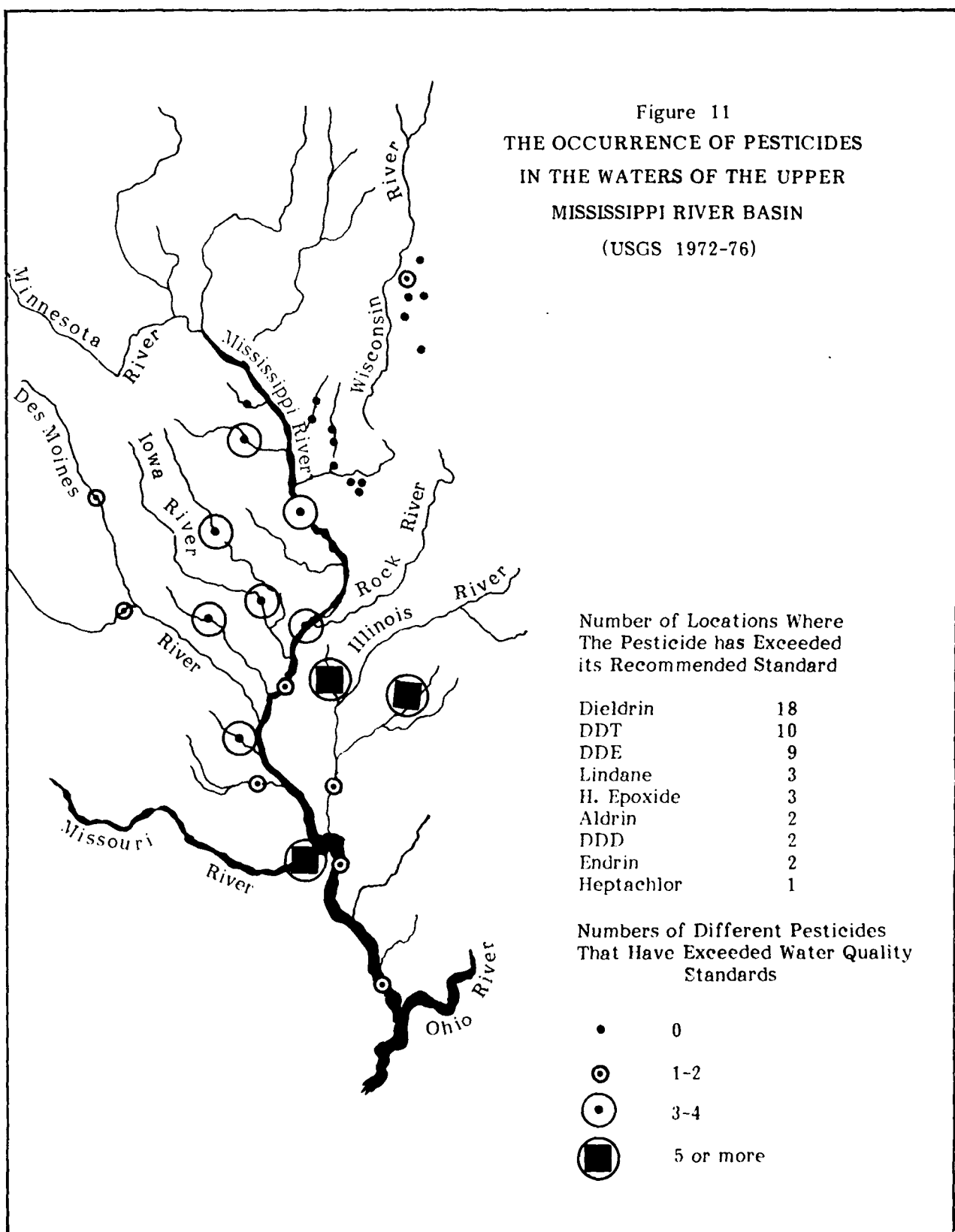


Table 5  
OCCURRENCE OF CHLORINATED HYDROCARBON INSECTICIDES  
IN THE UPPER MISSISSIPPI RIVER BASIN \*

Basin or Basin Segment	Number of Analysis	Dieldrin	DDT	DDE	Lindane	Aldrin	Endrin
Mississippi & Tribs. above Wisconsin River	0						
Wisconsin	64		1	1			
Mississippi & Tribs. between Wisconsin and Des Moines Rivers	638	248	47	158			
Mississippi & Tribs. between Des Moines and Missouri River	154	120	1		65	14	7
Mississippi & Tribs. below Missouri River	19	12					
Total for Mississippi Basin (except Missouri)	875	380	49	159	65	14	7

\* Date from approximately 1972-1976 USGS data.

summarizes the frequency of the detectable levels of chlorinated pesticides in the basin. Since this table summarizes information from many state and federal monitoring activities, the kinds of pesticides and the intensity of the sampling vary with time and place. Therefore, not all analyses tested for all pesticides, and many of the pesticides listed must have a higher frequency of occurrence than these data indicate.

Since most of the pesticide analyses were run at the 0.1 ug/l level of detection, (which is equal to or greater than the allowable concentrations for all the mentioned organochlorines except Endrin), all the detected levels of Dieldrin, DDT, DDE, Lindane, Heptachlor, Chlordane and Aldrin are in violation of standards for protection of aquatic life.

The threat to human health from acute toxicity of pesticides in drinking water appears to be no greater than the threat from PCBs and for the same reasons. These organochlorines have very low solubility in water and are found mostly in suspended sediments which are removed during water treatment.

The chlorinated hydrocarbons have been restricted in use for several years. The levels of Dieldrin and other chlorinated hydrocarbons measured during the last few years are mostly persistent residues from pesticide applications made years before. Therefore, while levels of the pesticides are not expected to rise, their continued restricted use and their gradual release from stream sediments will sustain the presence of these chemicals in streams for many more years. Dieldrin, for example, has had little change in its frequency during a recent 8 year period. A study of pesticide occurrence in the Missouri and Upper Mississippi Rivers showed about 40 percent of the samples contained Dieldrin between 1964 and 1967 (Schafer, et al, 1967), compared with 34 percent and 48 percent for the Missouri and Upper Mississippi Basins respectively, during 1972 through 1976. DDT, DDE and Endrin occurred in over 30 percent of the earlier samples but occurred with much less fre-

quency during the later period. The earlier survey found "only occasional" detectable amounts of Aldrin and Heptachlor, so the status of these pesticides has not greatly changed.

The state of Iowa has regularly sampled pesticide levels in streams for many years. Figure 12 summarizes some of their data. As the preceding data on the Upper Mississippi Basin showed, Dieldrin is of most concern, and DDE, a breakdown product of DDT, is more prevalent than DDT itself. The trend to note on the Mississippi is that frequencies of detectable limits (hence standards violations) increase dramatically from the northern to the southern end of Iowa as a result of pesticides in the large rivers draining the state.

Like PCBs, pesticides bioaccumulate in aquatic animals during their lifetime. The FDA has therefore set limits for acceptable levels of DDT and Dieldrin in fish flesh. A limit of 5 mg/kg has been set for DDT and 0.3 mg/kg for Dieldrin. No limits were set for any other pesticides. Table 6 summarizes data collected by several agencies on the contamination of fish flesh by pesticides. The 5 mg/kg limit for DDT was not approached in any of the locations sampled, but the 0.3 mg/kg limit for Dieldrin was approached in the Missouri River at Boonville and the Mississippi at Hannibal, and exceeded in the Mississippi at Chester, Illinois. Chlordane has no official limit, but its chemical similarity to Dieldrin and its concentration in fish flesh in the Missouri and Upper Mississippi Basins suggest it is as big a problem as Dieldrin.

The effects of long term sub-acute levels of pesticides are unknown. This kind of problem cannot be simulated in a laboratory, and therefore the safe daily dosage of a pesticide over a 60-year period is not known. Chronic low-level pesticide contamination would appear to be of more concern than acute toxicity from either drinking water or fish.

### C. Heavy Metals

Without exception, the heavy metals discussed below have very complex biogen-

Figure 12  
THE FREQUENCY OF  
OCCURRENCE OF THREE PESTICIDES  
IN IOWA STREAMS  
(April 1968 - October 1976)

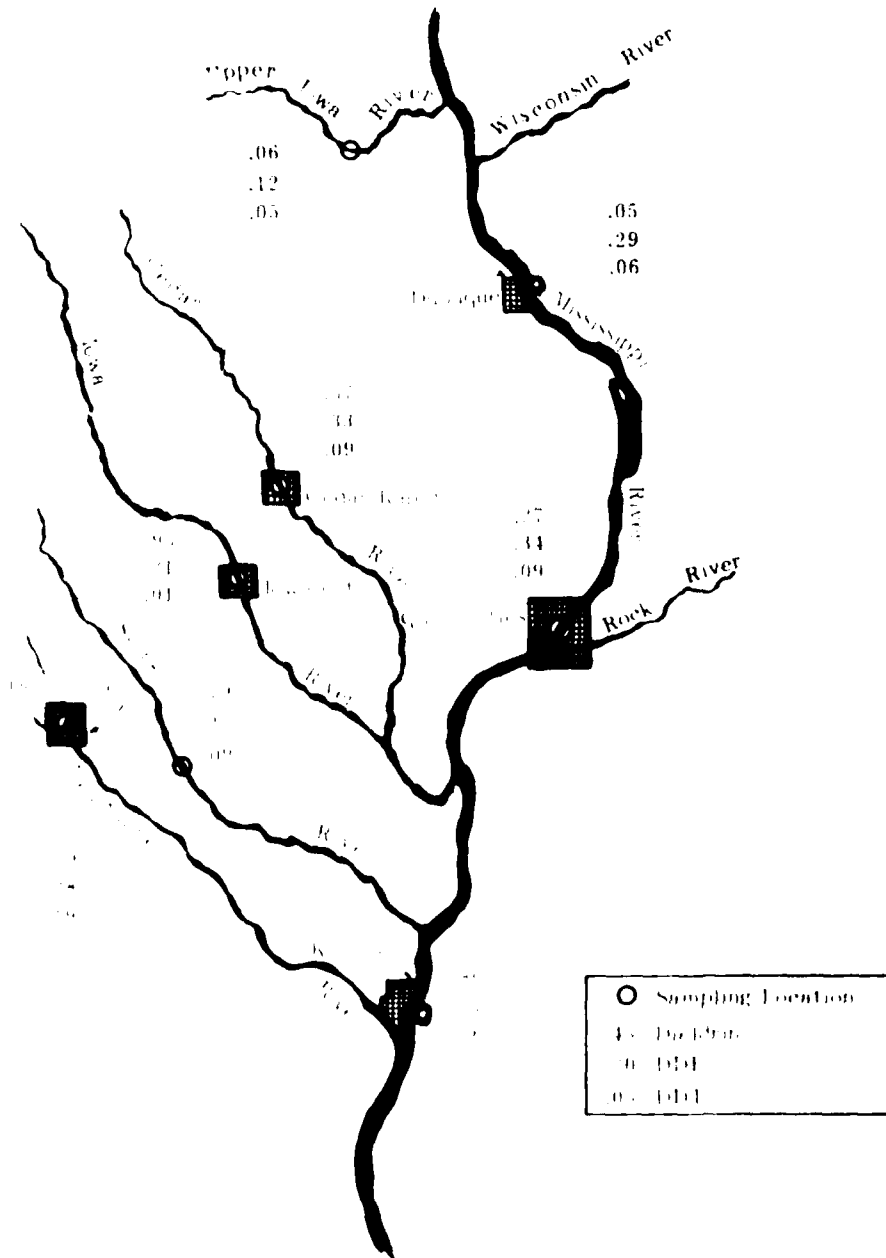


Table 6

LEVELS OF PESTICIDES IN THE TISSUES OF FISH FROM  
SEVERAL LOCATIONS IN THE UPPER MISSISSIPPI RIVER BASIN (mg/kg)

STREAM	LOCATION	DDT	DDE	DDD	CHLORDANE	DIELDRIN	HEPTACHLOR EPOXIDE
Missouri R.	Yankton, SD		23	16	12	9	
	Sioux City, IA		30		13		
	Omaha, NE		31		10	13	
	St. Joseph, MO	85	185	64	53	58	
Kansas R.	Kansas City, MO		42	19	31	23	
Missouri R.	Kansas City, MO		49		28	34	
	Boonville, MO				274	294	
	Jefferson City, MO		52		32	118	
Mississippi R.	Lansing, IA		1.3			2	
	Clinton, IA		30		20	12	
	Davenport, IA		22, 5.7		20, 7	21, 13.7	
Cedar R.			15		84	37	
Iowa R.			72	68	49	178	
Mississippi R.	Below Burlington, IA						3.6
Des Moines R.					141, 43	127, 47	
Mississippi R.	Warsaw, IL	84				81.2	5
	Meyer, IL	36.7				32	
	Quincy, IL	50				39	2
	Hannibal, MO				251	243	
	Louisiana, MO				117	104	
	Alton, IL				86	81	
	St. Louis, MO		23		94	202	
Meramec R.					65	18	
Mississippi R.	Chester, IL				333	499	
	Cape Girardeau, MO		37		52	101	
	Caruthersville, MO	66	205	208	63, 151	33, 116	

\*Data from Kansas Forestry, Fish and Game Comm. (1972); Iowa Conservation Commission (1976); Missouri Department of Conservation, Lorenz (1976).

chemical cycles. They move through the aquatic environment in water as ions or complexed with dissolved compounds. They can be adsorbed onto suspended or deposited sediments of both mineral and organic origin. Most importantly they can be incorporated into living tissue. The factors which control the pathways a metal can take through an aquatic community -- its rate, magnitude and impact on the biota -- are many.

The total amount of a metal present is important since the various forms in which it may exist (i.e., as an ion, bound onto or within particles or incorporated into living tissues) must follow the laws of chemical equilibria. Changes in the total amount of the metal can mediate a change in all forms of the metal. Therefore, a change in the amount of metal in the stream can change the amounts of all forms in which the metal is present, not just in the form which is entering the stream.

Alkalinity appears to greatly influence the toxicity of metals. Soft waters, those low in calcium bicarbonate, show much higher toxicity for a given concentration of a metal than waters rich in calcium carbonate and bicarbonate. The toxicity has generally been interpreted to be caused by the replacement of calcium by other metals, and the rate of substitution would be reduced in waters with abundant available calcium.

The presence and amount of complexing organic substances or metal adsorbing mineral or organic particles regulates the equilibrium concentrations of a given amount of a metal. In some cases these binding agents hold the metal so tightly that it is effectively removed from use by the aquatic biota. In other cases the metal may be loosely bound and released after only a minor change in water chemistry. As it is regulated by the amount of metal, the equilibrium is also regulated by the character and quantity of these complexing substances and adsorbing materials. Therefore, periods of high surface runoff could change the amount of metals entering a stream, the alkalinity and also the amount of metal adsorbing particles suspended in the water. Increases in the concentration

of dissolved organics in water caused by autumnal leaf fall and winter runoff from decomposing organic matter would increase the potential for complexing metal ions to organic substances.

Tables 7 A-L present data on the occurrence of heavy metals in the Upper Mississippi River Basin.

Of the twelve metals shown in Tables 7 A-L, eight showed violations of water quality standards which are presented in Table 8. Those metals: cadmium, copper, lead, manganese, zinc, silver, iron and mercury, are discussed below. Tables 9 and 10 present the frequency of violations of aquatic life standards and of drinking water standards by heavy metals.

Cadmium: There was only one violation noted. This occurred in the St. Louis area. Although cadmium is quite toxic to most aquatic life, the very low frequency of violations in the Upper Mississippi River indicate that cadmium pollution is not a problem.

Copper: The pattern of copper violations is distinct. There are frequent violations in the Dubuque to Burlington segment, but no further violations until the St. Louis metropolitan area. Several forms of copper occur in water, and their toxicity is quite variable. Evidence of a copper pollution problem, therefore, is not documented by this data. The bicarbonate nature of the Mississippi is a positive factor in reducing the impact of ambient levels of copper on the biota of the river. The area of greatest concern appears to be below St. Louis.

Lead: Lead analyses shows this metal to be a problem mainly in the GREAT II segment of the river. Lead is toxic and accumulates in man and other animals. The frequency with which the drinking water and aquatic life standards are violated indicate that long-term lead accumulation might be a health problem.

Manganese: This secondary drinking water standard is almost always exceeded for the entire Upper Mississippi River. The

Table 7A  
ARSENIC

	River Mile	Major Dischargers	Sta. No.	Avg. Total Metal Conc. mg/l	# of Samples	% of Samples Exceeding Standard	
						aquatic life	drinking water
	386.5	John Deere Co.				No	
	579		1	.000	16	Std.	0
	577	Dubuque Stp. **					
	537		2	.000	8		0
	520		3	.000	13		0
	513-517	Clinton Stp., E.I. Dupont, Hawkeye Chem.					
	512		GS*	.002	11		0
	507	Wapsipinicon River					
	503		4	.000	9		0
	496		5	.000	12		0
	485		6	.000	9		0
	481	Davenport Stp. Rock River					
	479						
	455.5		7	.000	12		0
		Muscatine Stp. Monsanto					
	437		8	.000	9		0
	424	Iowa River					
	410.5		9	.000	10		0
	402	Burlington Stp. Skunk River					
	396						
	384		10	.000	9		0
	383	Ft. Madison Stp., Con. Pkg., Armour-Dial					
	361.5		GS	.003	13		0
	361.2		11	.000	10		0
	363	Keokuk Stp. Hubinger					
	361.5	Des Moines River					
	343		12				
	327		13	.000	13		0
	319-325	Quincy Stp. American Cyanamid					
	285		14	.000	10		0
	241		15	.001	10		0
	218	Illinois River					
	204		16	.001	3		0
	202		GS	.006	14		0
	196.5	Missouri River					
	190		17				
	184		18	.004	2		0
	186	Reiser Pl. Stp.					
	172	Leary Stp.					
	170		19	.002	2		0
	149		20	.001	14		0
	50		21				
	44	Cape Girardeau Stp.					
	1		GS	.005	23		0
			22	.001	11		0

\* U.S.S. Sampling Station

\*\* Stp. Sewage Treatment Plant

Table 7B  
CADMIUM

	River Mile	Major Dischargers	Sta. No.	Avg. Total Metal Conc. mg/l	# of Samples	% of Samples Exceeding Standard	
						aquatic life	drinking water
	586.5	John Deere Co.					
	579		1	.000	16	0	0
	577	Dubuque Stp.					
	537		2	.000	6	0	0
	520		3	.000	13	0	0
	513-517	Clinton Stp., E.I. Dupont, Hawkeye Chem.					
	512		GS*	.002	10	0	0
	507	Wapsipinicon River					
	503		4	.000	9	0	0
	496		5	.000	12	0	0
	485		6	.000	9	0	0
	481	Davenport Stp.					
	479	Rock River					
	455.5		7	.000	12	0	0
		Muscatine Stp. Monsanto					
	437		8	.000	9	0	0
	434	Iowa River					
	410.5		9	.000	10	0	0
	402	Burlington Stp.					
	396	Skunk River					
	384		10	.000	10	0	0
	383	Ft. Madison Stp., Con. Pkg., Armour-Dial					
	364.2		GS	.002	13	0	0
	364.2		11	.000	10	0	0
	363	Keokuk Stp. Hubinger					
	361.5	Des Moines River					
	343		12				
	327		13	.000	10	0	0
	319-325	Quincy Stp. American Cyanamid					
	283		14	.000	11	0	0
	241		15	.000	11	0	0
	218	Illinois River					
	204		16	.000	6	0	0
	203		GS	.005	16	6	0
	195.5	Missouri River					
	192		17	.000	2	0	0
	184		18	.000	3	0	0
	183	Bissel Pt. Stp.					
	172	Lemay Stp.					
	170		19	.000	12	0	0
	110		20	.000	9	0	0
	55		21				
	50	Cape Girardeau Stp.					
	44		GS	.006	25	0	0
	41		22	.002	12	0	0

\* USGS Sampling Station

Table 7C  
HEXAVALENT CHROMIUM

	River Mile	Major Dischargers	Sta. No.	Avg. Total Metal Conc. mg/l	# of Samples	% of Samples Exceeding Standard	
						aquatic life	drinking water
	556.5	John Deere Co.	1	.000	10	0	0
	559						
	577	Dubuque Stp.	2	.000	8	0	0
	537		3	.000	12	0	0
	520						
	513-517	Clinton Stp., E.I. DuPont, Hawkeye Chem.	GS*				
	512						
	507	Wapsipineon River					
	503		4	.000	9	0	0
	496		5	.000	12	0	0
	485		6	.000	9	0	0
	481	Davenport Stp.					
	479	Rock River					
	455.5		7	.000	12	0	0
		Muscatine Stp. Monsanto					
	437		8	.000	9	0	0
	434	Iowa River					
	410.5		9	.000	10	0	0
	402	Burlington Stp.					
	396	Skunk River					
	384		10	.000	9	0	0
	383	St. Madison Stp., Con. Pkg., Armour-Dial					
	364.2		GS				
	364.2		11	.000	10	0	0
	363	Keokuk Stp. Hubinger					
	361.5	Des Moines River					
	343		12				
	327		13	.000	10	0	0
	319-325	Quincy Stp. American Cyanamid					
	283		14	.000	10	0	0
	241		15	.000	10	0	0
	218	Illinois River					
	204		16	.000	6	0	0
	203		GS				
	195.5	Missouri River					
	192		17	.000	3	0	0
	184		18	.000	3	0	0
	183	Bessel Pl. Stp.					
	172	Lemay Stp.					
	170		19	.000	12	0	0
	110		20	.000	12	0	0
	55		21				
	30	Cape Girardeau Stp.					
	14		GS				
	1		22	.000	12	0	0

\* U.S.C.S. Sampling Station

Table 7D  
TRIVALENT CHROMIUM

	River Mile	Major Dischargers	Sta. No.	Avg. Total Metal Conc. mg/l	# of Samples	% of Samples Exceeding Standard	
						aquatic life	drinking water
	586.5	John Deere Co.					
	579		1	.00	10	0	0
	577	Dubuque Stp.	2	.00	8	0	0
	537		3	.00	12	0	0
	520						
	513-517	Clinton Stp., E.I. Dupont, Hawkeye Chem.					
	512		GS*				
	507	Wapsipineon River					
	503		4	.00	9	0	0
	496		5	.00	12	0	0
	485		6	.00	9	0	0
	481	Davenport Stp., Rock River					
	479						
	455.5	Muscatine Stp., Monsanto	7	.00	12	0	0
	437		8	.00	9	0	0
	434	Iowa River					
	410.5		9	.00	10	0	0
	402	Burlington Stp., Skunk River					
	396		10	.00	9	0	0
	384						
	383	Ft. Madison Stp., Con. Pkg., Armour-Dial					
	364.2		GS				
	364.2		11	.00	10	0	0
	363	Keokuk Stp., Hubinger					
	361.5	Des Moines River					
	343		12				
	327		13	.00	10	0	0
	319-325	Quincy Stp., American Cyanamid					
	283		14	.00	10	0	0
	241		15	.00	10	0	0
	218	Illinois River					
	204		16	.00	3	0	0
	203		GS				
	195.5	Missouri River					
	192		17	.00	2	0	0
	184		18	.02	3	0	0
	183	Bissel Pl. Stp., Lemay Stp.					
	172						
	170		19	.01	12	0	0
	110		20	.00	11	0	0
	55		21				
	50	Cape Girardeau Stp.					
	44		GS				
	1		22	.01	11	0	0

\* USGS Sampling Station

Table 7F  
COPPER

	River Mile	Major Dischargers	Sta. No.	Avg. Total Metal Conc., mg/l	# of Samples	% of Samples Exceeding Standard	
						aquatic life	drinking water
	586.5	John Deere Co.					
	579		1	.03	16	19	0
	577	Dubuque Stp.					
	537		2	.03	8	50	0
	520		3	.03	18	22	0
	513-517	Clinton Stp., E.L. DuPont, Hawkeye Chem.					
	512		GS*	.012	10	10	0
	507	Wapsipawicon River					
	503		4	.01	9	12	0
	496		5	.04	12	33	0
	485		6	.03	9	22	0
	481	Davenport Stp., Rock River					
	479						
	457.5	Muscatine Stp., Monsanto	7	.05	12	42	0
	437		8	.04	9	33	0
	434	Iowa River					
	410.5		9	.02	10	10	0
	402	Burlington Stp., Skunk River					
	396						
	384		10	.00	10	0	0
	385	Ft. Madison Stp., Con. Plg., Armour-Dial					
	364.2		GS	.009	13	0	0
	364.2		11	.00	10	0	0
	363	Keokuk Stp., Hubinger					
	361.5	Des Moines River					
	343		12				
	327		13	.00	10	0	0
	319-325	Quincy Stp., American Cyanamid					
	283		14	.00	11	0	0
	241		15	.00	11	0	0
	218	Illinois River					
	204		16	.01	6	18	0
	203		GS	.038		82	0
	195.5	Missouri River					
	192		17	.05	2	50	0
	184		18	.03	3	33	0
	183	Bessel Pt. Stp., Levee Stp.					
	172						
	170		19	.06	13	54	0
	149		20	.18	12	83	0
	55		21				
	50	Cape Girardeau Stp.					
	44		GS	.03	25	56	0
	1		22	.01	12	18	0

\* U.S.S. Sampling Station

Table VI  
LEAD

	River Mile	Major Dischargers	Sta. No.	Avg. Total Metal Conc., mg/l	# of Samples	% of Samples Exceeding Standard	
						aquatic life	drinking water
	586.5	Iowa River	1	.08	16	6	12
	579	Dubuque Stp.	2	.10	7	29	43
	577		3	.07	18	17	22
	537	Clinton Stp., E.I.L.					
	520	Dupont, Hawkeye Chem.					
	513-517						
	512	Wapsipicon River	GS*	.02	10	0	10
	507						
	503		4	.02	9	11	11
	496		5	.04	12	17	25
	485		6	.04	9	22	22
	481	Davenport Stp., Rock River					
	479						
	455.5	Muscatine Stp., Monsanto					
	437		8	.08	9	22	33
	431	Iowa River					
	410.5		9	.05	10	30	40
	402	Burlington Stp., Skunk River					
	396						
	384		10	.00	09	0	0
	383	Fl. Madison Stp., Gen. Pkg., Armour-Dial					
	364.2		GS	.02	13	0	8
	364.2		11	.00	10	0	0
	363	Keokuk Stp., Hubinger					
	361.5	Des Moines River					
	343		12				
	324		13	.00	10	0	0
	319-325	Quincy Stp., American Cyanamid					
	283		14	.00	10	0	0
	241		15	.00	10	0	0
	218	Illinois River					
	204		16	.00	6	0	0
	203		GS	.03	16	0	36
	195.5	Missouri River					
	192		17	.01	2	0	0
	184		18	.02	3	0	0
	183	Peoria Stp.					
	172	Gen. Stp.					
	150		19	.02	13	0	0
	140		20	.02	12	0	0
	55		21				
	50	Cape Girardeau Stp.					
	44		GS	.06	25	0	56
	1		22	.01	12	0	0

\* USGS Sampling Station

Table 76  
 DATA

	River Mile	Major Dischargers	Sta. No.	Avg. Total Metal Conc., mg/l	# of Samples	# of Samples Exceeding Standard	
						Lead	Copper
	566.7	Dubuque Stp.	1	.16	10	0	100
	559		2	.16	8	0	100
	557		3	.15	13	0	100
	557	Clinton Stp., E.L.					
	550	Duquoy, Hawkeye Chem.					
	513-517						
	512		GS*	.25	10	0	100
	507	Wapsipicon River					
	503		4	.13	9	0	100
	496		5	.16	12	0	100
	485		6	.15	9	0	100
	481	Davenport Stp.					
	479	Rock River					
	455.5		7	.18	12	0	100
		Muscatine Stp.					
		Monsanto					
	437		8	.14	9	0	100
	434	Iowa River					
	410.5		9	.28	10	0	90
	392	Burlington Stp.					
	392	Sioux River					
	384		10	.20	10	0	100
	383	St. Madison Stp., Chem. Pkg., Armour Dred					
	364.7		GS	.14	14	0	100
	364.2		11	.15	10	0	100
	363	Keokuk Stp., Hubinger					
	361.5	Des Moines River					
	343		12				
	327		13	.14	10	0	100
	319-325	Quincy Stp., American Cyanamid					
	283		14	.15	11	0	82
	241		15	.24		0	100
	238	Platte River					
	204		16	.16	6	0	83
	205		GS	.25	16	0	100
	195.5	Missouri River					
	192		17	.12	2	0	100
	184		18	.40	3	0	100
	183	Basel Fr. Stp.					
	172	Lehigh Stp.					
	170		19	.30	12	0	92
	110		20	.27	12	0	100
	66		21				
	50	Cape Girardeau Stp.					
	41		GS	.26	25	0	100
	1		22	.23	12	0	92

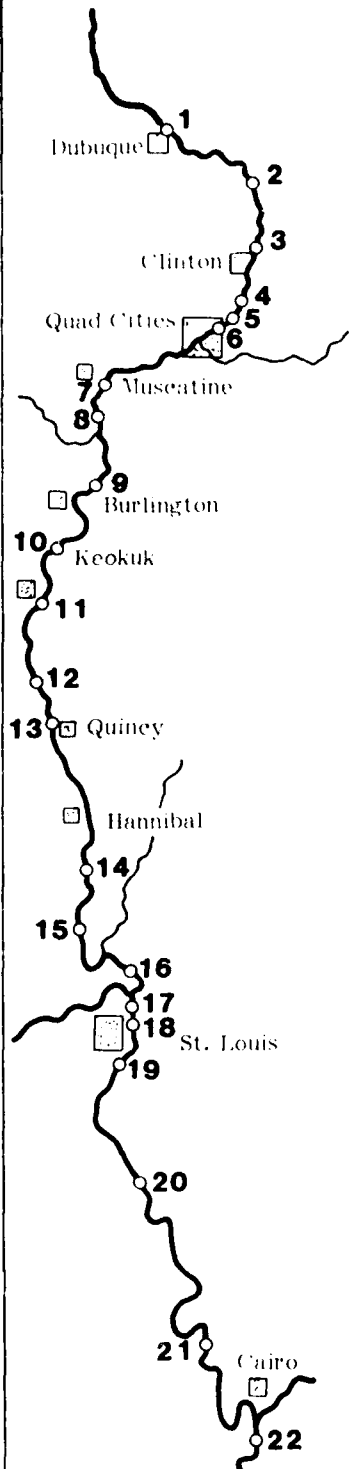
\* U.S. Geological Station

Table 7H  
ZINC

	River Mile	Major Dischargers	Sta. No.	Avg. Total Metal Conc., mg/l	# of Samples	of Samples Exceeding Standard	
						1967	1968
	586.5	Iowa Des Moines Co.	1	.0	10	0	0
	579	Dubuque Stp.	2	.0	8	0	0
	577		3	.0	13	0	0
	537	Clinton					
	520						
	513-517	Clinton Stp., L.I.I. Dupont, Hawkeye Chem.					
	512		GS*	.048	10	0	0
	507	Wapsipumicon River					
	503		4	.0	9	0	0
	496		5	.0	12	0	0
	485		6	.0	9	0	0
	481	Davenport Stp.					
	479	Rock River					
	455.5		7	.0	12	0	0
		Muscatine Stp. Monsanto					
	437		8	.1	9	11	0
	434	Iowa River					
	410.5		9	.0	10	0	0
	402	Burlington Stp.					
	396	Skunk River					
	384		10	.0	10	0	0
	383	Ft. Madison Stp., Con. Pkg., Armour-Dial					
	364.2		GS	.027	13	0	0
	364.2		11	.0	10	0	0
	363	Keokuk Stp. Hubinger					
	361.5	Des Moines River					
	343		12				
	327		13	.0	10	0	0
	319-325	Quincy Stp. American Cyanamid					
	283		14	.0	11	0	0
	241		15	.0	11	0	0
	218	Illinois River					
	204		16	.8	6	17	0
	203		GS	.68	16	0	0
	195.5	Missouri River					
	192		17	.0	2	0	0
	184		18	.0	3	0	0
	183	Bessel Pt. Stp.					
	172	Levee Stp.					
	170		19	.1	12	8	0
	110		20	.0	12	0	0
	55		21				
	50	Cape Girardeau Stp.					
	44		GS	.07	25	0	0
	1		22	.0	14	0	0

\* USGS Sampling Station

Table 41  
SILVER

	River Mile	Major Dischargers	Sta. No.	Avg. Total Metal Conc., mg/l	# of Samples	% of Samples Exceeding Standard	
						aqueous phase fish	water
Dubuque	586.5	John Deere Co.	1	.000	10	0	0
	579						
	577	Dubuque Stp.	2	.000	8	0	0
Clinton	537		3	.000	13	0	0
	520						
Quad Cities	513-517	Clinton Stp., E.I. Dupont, Hawkeye Chem.					
			GS*				
Muscatine	512						
	507	Wapsipineon River	4	.000	9	0	0
	503		5	.000	12	0	0
	496		6	.000	9	0	0
Burlington	485						
	481	Davenport Stp.					
Keokuk	479	Rock River	7	.000	12	0	0
	455.5						
		Muscatine Stp. Monsanto					
	437		8	.000	9	0	0
	434	Iowa River					
	410.5		9	.002	10	10	0
Quincy	402	Burlington Stp.					
	396	Skunk River					
	384		10	.000	10	0	0
	383	Ft. Madison Stp., Con. Pkg., Armour- Dial					
			GS				
	364.2		11	.000	10	0	0
	364.2						
	363	Keokuk Stp. Hubinger					
	361.5	Des Moines River	12				
	343		13	.001	10	10	0
	327						
	319-325	Quincy Stp. American Cyanamid					
	283		14	.000	10	0	0
	241		15	.000	10	0	0
	218	Illinois River					
	204		16	.000	6	0	0
	203		GS				
	195.5	Missouri River					
	192		17	.000	2	0	0
	184			.000	3	0	0
	183	Bissel Pt. Stp.					
	172	Lemay Stp.					
	170		19	.000	12	0	0
	110		20	.000	12	0	0
	55		21				
	50	Cape Girardeau Stp.					
	44		GS				
	1		22	.000	12	0	0

\* USGS Sampling Station

Table 7J  
NICKEL

	River Mile	Major Dischargers	Sta. No.	Avg. Total Metal Conc., mg/l	# of Samples	% of Samples Exceeding Standard	
						aquatic life	drinking water
	586.5	John Deere Co.					
	579		1	.0	10	0	No Std
	577	Dubuque Stp.	2	.0	8	0	
	537		3	.0	13	0	
	520						
	513-517	Clinton Stp., E.I. Dupont, Hawkeye Chem.					
	512		GS*				
	507	Wapsipineon River					
	503		4	.0	9	0	
	496		5	.0	12	0	
	485		6	.0	9	0	
	481	Davenport Stp.					
	479	Rock River					
	455.5		7	.0	12	0	
		Muscatine Stp.					
		Monsanto					
	437		8	.0	9	0	
	434	Iowa River					
	410.5		9	.0	10	0	
	402	Burlington Stp.					
	396	Skunk River					
	384		10	.0	10	0	
	383	Ft. Madison Stp., Con. Pkg., Armour Dial					
	364.2		GS				
	364.2		11	.0	10	0	
	363	Keokuk Stp. Hubinger					
	361.5	Des Moines River					
	343		12				
	327		13	.0	10	0	
	319-325	Quincy Stp. American Cyanamid					
	283		14	.0	11	0	
	241		15	.0	11	0	
	218	Illinois River					
	201		16	.0	6	0	
	203		GS				
	195.5	Missouri River					
	192		17	.0	2	0	
	181		18	.0	3	0	
	183	Bessel Pt. Stp.					
	172	Lemay Stp.					
	170		19	.0	12	0	
	110		20	.0	12	0	
	55		21				
	50	Cape Girardeau Stp.					
	44		GS				
	1		22	.0	12	0	

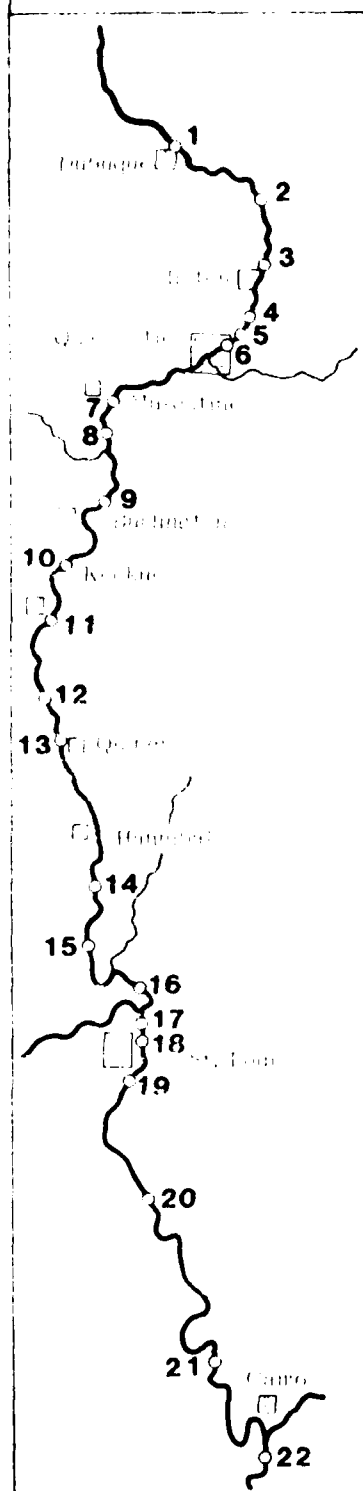
\* USGS Sampling Station

Table IX

UPPER

River Miles	Major Discharges	Sta. No.	Avg. Total Metal Conc., mg/l	# of Samples	Percent of Samples Exceeding Standard	
					Lead	Cadmium
	Dubuque	1	589.5			
		2	379			
		3	377			
	Clinton	4	537			
		5	520			
	Quad Cities	6	513-517			
		7	512			
	Muscatine	8	507			
		9	503			
		10	496			
	Burlington	11	485			
		12	481			
	Keokuk	13	479			
		14	455.5			
		15	437			
		16	434			
		17	410.5			
	Quincy	18	402			
		19	396			
		20	384			
	Hannibal	21	383			
		22	364.2			
		23	364.2			
		24	363			
		25	361.5			
		26	343			
		27	327			
	St. Louis	28	319-325			
		29	282			
		30	241			
		31	218			
		32	264			
		33	265			
		34	195.5			
		35	192			
		36	181			
		37	183			
		38	172			
		39	179			
		40	150			
		41	75			
		42	59			
		43	44			
		44	1			

\* USGS Sampling Station



Recess Miles	Place Interchange	Sta- tion	1900	1901	1902	1903
186.0	At the Depot, Cal.					
187		1	1.0	1.0	1.0	1.0
187	Doniphan Stn.			0	0	0
187		1	1.0	1.0	1.0	1.0
187	Clinton Stn., Ill.					
187	DuPont, Delaware					
187	Chico	18	1.4	1.4	1.4	1.4
187	Wapiti (North) River					
187		1	1.0	1.0	1.0	1.0
187		1	1.0	1.0	1.0	1.0
187		1	1.0	1.0	1.0	1.0
187	Tracy (West) Stn.					
187	Rock River					
187		1	1.0	1.0	1.0	1.0
187	Thompson Stn.					
187	Marquette					
187		8	1.0	1.0	1.0	1.0
187	Lower River					
187		1	1.0	1.0	1.0	1.0
187	Parthenon St.					
187	Stark River					
187		10	1.0	1.0	1.0	1.0
187	Thompson Stn.					
187	Long Point, Ontario					
187	Dial	18	1.5	1.5	1.5	1.5
187		10	1.0	1.0	1.0	1.0
187	Knox Stn., Indiana					
187	Doniphan River					
187		1	1.0	1.0	1.0	1.0
187		1	1.0	1.0	1.0	1.0
187	Quincy Stn.					
187	Artesian Channel					
187		11	1.0	1.0	1.0	1.0
187		1	1.0	1.0	1.0	1.0
187	Illinois River					
187		1	1.0	1.0	1.0	1.0
187		1	1.0	1.0	1.0	1.0
187		1	1.0	1.0	1.0	1.0
187	Missouri River					
187		1	1.0	1.0	1.0	1.0
187		1	1.0	1.0	1.0	1.0
187	Beck Pl., Stn.					
187	Leamy Stn.					
187		10	1.3	1.3	1.3	1.3
187		10	1.0	1.0	1.0	1.0
187		1	1.0	1.0	1.0	1.0
187	Cape Girardeau Stn.					
187		1	1.0	1.0	1.0	1.0
187		1	1.0	1.0	1.0	1.0

[illegible]

Table 8

U.S. E.P.A. WATER QUALITY STANDARDS FOR HEAVY METALS (ug/l)

<u>Metal</u>	<u>Aquatic Life Standard</u>	<u>Drinking Water Standard</u>
Arsenic	--	50
Cadmium	12 *	10
Chromium	100	50
Copper	20 **	1,000
Lead	100 *	50
Manganese	1,000	50
Zinc	300 *	5,000
Silver	5	50
Nickel	1,000	--
Iron	1,000	300
Mercury	.05	2

\* Use of this figure assumes "hard water."

\*\* Based upon interpretation of toxicity test data on sensitive resident species by the state of Missouri.

Table 9

FREQUENCY OF AQUATIC LIFE STANDARDS VIOLATIONS  
BY HEAVY METALS

LOCATION	METAL										
	As.	CD.	CR+ <sup>6</sup>	CR+ <sup>3</sup>	Cu.	Pb.	Mn.	Zn.	Ag.	Fe.	Hg.
Dubuque, IA					.19	.06				.10	
Near Sabula, IA					.50	.29				.12	
Above Clinton, IA					.22	.17				.08	
Clinton, IA*					.10					.70	.91
Below Clinton, IA					.12	.11				.22	
Above E. Moline, IL					.33	.17				.33	
E. Moline, IL					.22	.22				.22	
Muscatine, IA					.42	.25				.50	
Below Muscatine, IA					.33	.22		.11		.11	
Above Burlington, IA					.10	.30			.10	.30	
Ft. Madison, IA										.40	
Keokuk, IA*										.42	.92
Keokuk, IA										.20	
Quincy, IL									.10	.30	
Louisiana, MO										.27	
Winfield, MO										.45	
Alton, IL					.18			.17		.50	
Below Alton, IL*			.06		.82					.75	.35
Above St. Louis, MO					.50					1.00	
St. Louis, MO					.33					1.00	.67
Below St. Louis, MO					.54			.08		.92	.30
Chester, IL					.83					.92	
Thebes, IL*					.56					1.00	.70
Below Cairo, IL					.18					.92	

\*USGS data - all others are Illinois EPA

Table 10

FREQUENCY OF DRINKING WATER STANDARDS VIOLATIONS  
BY HEAVY METALS

LOCATION	METAL										
	As.	Cd.	CR <sup>+6</sup>	CR <sup>+3</sup>	Cu.	Pb.	Mn.	Zn	Ag.	Fe.	Hg.
Dubuque, IA						.12	1.00			.90	
Near Sabula, IA						.43	1.00			.67	
Above Clinton, IA						.22	1.00			.69	
Clinton, IA*						.10	1.00			1.00	
Below Clinton, IA						.11	1.00			.67	
Above E. Moline, IL						.25	1.00			.92	
E. Moline, IL						.22	1.00			.67	
Muscatine, IA						.42	1.00			.92	
Below Muscatine, IA						.33	1.00			.78	
Above Burlington, IA						.40	.90			.90	
Ft. Madison, IA							1.00			.80	
Keokuk, IA*						.08	1.00			1.00	
Keokuk, IA							1.00			.55	
Quincy, IL							1.00			.70	
Louisiana, MO							.82			.55	
Winfield, MO							1.00			.73	
Alton, IL							.83			.83	
Below Alton, IL*						.36	1.00			1.00	
Above St. Louis, MO							1.00			1.00	
St. Louis, MO							1.00			1.00	.67
Below St. Louis, MO							.92			1.00	.15
Chester, IL							1.00			1.00	
Thebes, IL*						.56	1.00			1.00	.04
Below Cairo, IL							.92			1.00	

\*USGS data - all other are Illinois EPA

main problems are the staining of laundry and the taste of the water. High levels of iron may aggravate the adverse effects of manganese.

Zinc: The standards for protection of aquatic life were occasionally exceeded at scattered locations (below Muscatine, Iowa, below the mouth of the Illinois and below St. Louis). As with copper, bicarbonate waters act to reduce zinc toxicity.

Silver: Only two measurements, one above Burlington and one at Quincy, showed significant levels of silver resulting in violations of the aquatic life standard. Since different silver compounds have widely varying toxicities, the importance of silver as a pollutant in the Upper Mississippi is questionable.

Iron: Laboratory tests show many aquatic animals are adversely affected by iron at concentrations commonly found in streams. Often, however, these laboratory results do not parallel toxicities in natural waters. Above the mouth of the Illinois, the standard for protection of aquatic life is exceeded less than 50 percent of the time at all locations except the USGS station at Clinton, but below the Illinois, it is exceeded 50 percent of the time or more at all locations sampled. This sharp rise in frequency of standard violations as well as the increase in average concentration may present significant adverse effects to the biota of the Mississippi below the Illinois River. The drinking water standard, like the one for manganese, is an aesthetic one. Like manganese, the standard for iron is consistently exceeded at all locations on the Mississippi. The main problems are staining of laundry and water taste.

Mercury: Violations of the mercury standard occurred in the St. Louis area (aquatic life and drinking water) and below Hannibal (aquatic life). Mercury poisoning is usually the result of industrial exposure or by ingestion of contaminated food rather than through contamination of water. Four of 16 measurements in the St. Louis area exceeded the drinking water standard, however, and suggest that mercury levels should be of concern.

### Heavy Metal Contamination of the Biota

Metals are not only a problem in water but in aquatic animals. This has been recognized by the F.D.A., which has imposed a limit of 0.5 mg/kg mercury in fish shipped to interstate markets. Canada uses this figure and sets a 5 mg/kg limit for arsenic, a 10 mg/kg level of lead and a 100 mg/kg level for copper and zinc.

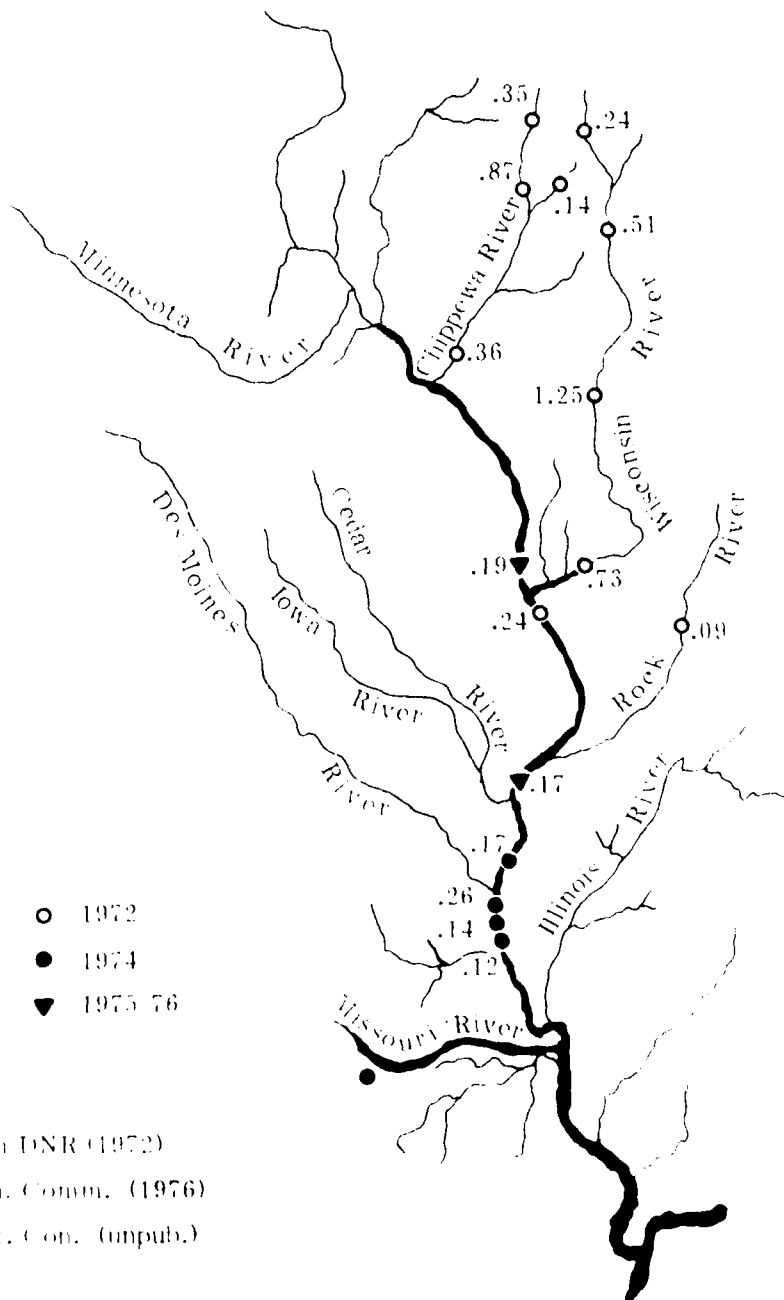
Mercury is of special concern since research has shown that any form of mercury can be microbially converted to methylmercury, which is readily assimilated by the biota. Studies of mercury contamination in a flowage in Ontario (Armstrong, 1973) showed that mercury concentrations were higher in deeper, more quiescent parts of the lake. These findings were apparently corroborated by studies in Wisconsin on mercury levels in ducks. Diving ducks, which feed in deeper waters, had higher levels of mercury than puddle ducks which feed in shallow waters. The increase of mercury in diving duck tissues was 33 percent and in the liver 100 percent over that of puddle ducks (Wisconsin DNR, 1972). However, the diving ducks may be at a somewhat higher trophic level than the puddle ducks. In the same study it was found that the average mercury concentration in fish tissues\* exceeded the FDA 0.5 mg/kg limit in most of the Wisconsin River as well as the Lower Flambeau and the middle section of the Chippewa Flowage. The state of Wisconsin advised that no more than one meal per week be made from fish caught in these areas. At that time the average tissue mercury level in fish in the Mississippi River where it borders Wisconsin was 0.24 mg/kg.

During 1975-1976 mercury determinations made on northern pike by the Iowa Conservation Commission (1976) showed that fish taken in the area where the 1972 survey was made showed mercury levels of 0.19 mg/kg. Further south, below Davenport, the average concentration was 0.17 mg/kg. This and other information on mercury levels in fish is shown in Figure 13.

There is not a substantial amount of information on what normal background levels of

\*33 percent rough fish, 67 percent game fish.

Figure 13  
MERCURY LEVELS IN  
FISH TISSUE IN THE FISH OF THE UPPER  
MISSISSIPPI RIVER BASIN\*  
(mg/kg)



\*Wisconsin DNR (1972)

Iowa Con. Comm. (1976)

Mo. Dept. Con. (unpub.)

mercury should occur in fish. Since it is retained and released very slowly from the body, mercury can be found in virtually all fish. Statewide surveys in Michigan and Wisconsin from a variety of streams found detectable traces of mercury in all fish sampled (Michigan DNR, 1972; Wisconsin DNR, 1972). Background values ranging from 0.04 to 0.76 mg/kg and 0.03 to 0.18 mg/kg have been reported from Canada and Sweden respectively (Wisconsin DNR, 1972). It appears, therefore, that levels in fish of the Upper Mississippi River are within or only slightly above background levels, and that reductions in point source mercury loading may help tributary streams, but should have little effect on the levels in Mississippi River fish.

Unlike other metals, there has been evidence of bioconcentration of mercury. A Swedish study found highest levels in northern pike. The Michigan study also showed higher levels of mercury in predator fishes. Information from Illinois EPA when plotted as mercury concentration against body length \* is shown in Figure 14. Since an individual of any species bioaccumulates mercury throughout its lifetime, mercury concentration increases with age and all data points for one species should follow a general trend of aligning along a line from lower left to upper right. The dashed lines separate species or groups of species from those accumulating mercury at different rates. The highest rates of accumulation occur among those species which feed mostly on invertebrates and other fish. Those species which feed mostly on herbaceous or detrital material appear to accumulate mercury at lower rates.

This information indicates that, as in other waters, mercury is being bioconcentrated in the Mississippi River.

There is less information on the concentration of other heavy metals in fish and how these relate to concentrations in sediments and in the water. This type of study,

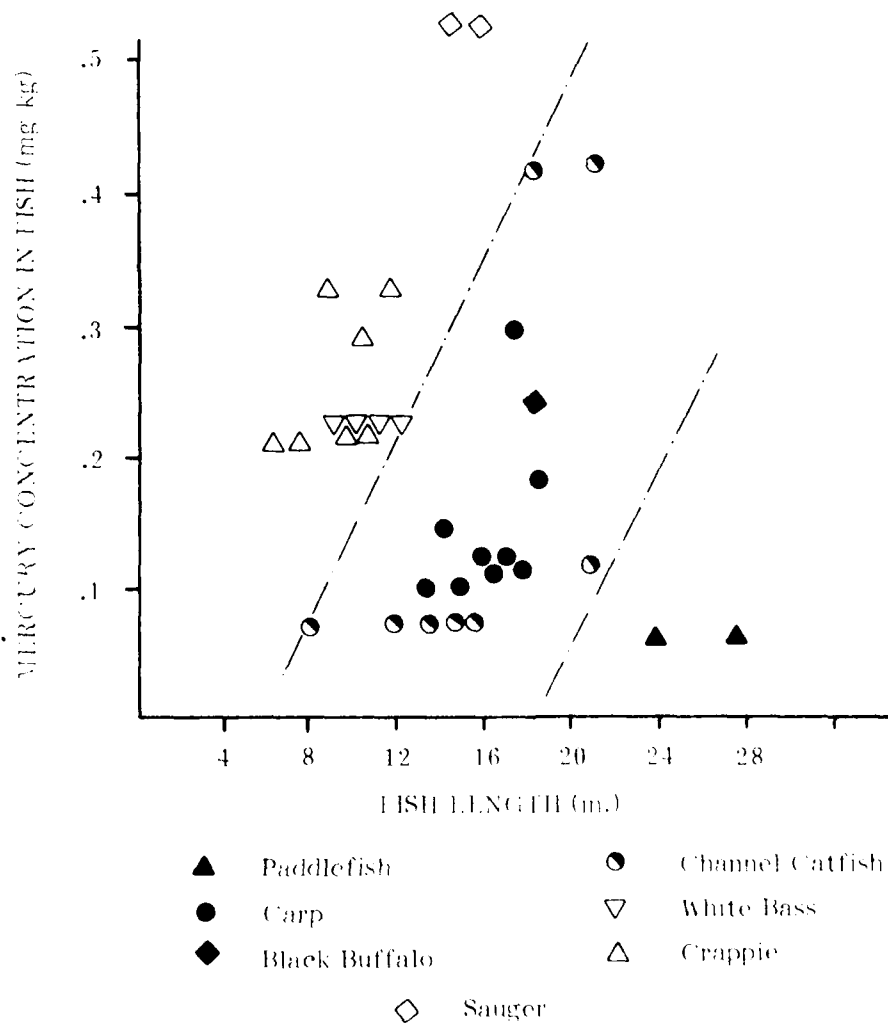
however, has been done in Michigan and Wisconsin (Michigan DNR, 1972; Wisconsin DNR, 1974). Both studies found that chromium content in fish is strongly correlated with chromium content in the water. The Michigan study found that for zinc and copper the same was true. This study also found that zinc and copper accumulated most heavily in bottom feeders, suggesting that these metals do not bioconcentrate, that they are eliminated from the body more easily and that the richest source of these metals is probably bottom sediments rather than any member of the food chain. The Michigan study found lead levels in fish were about the same in areas of lead contamination and in areas with only background levels of lead in the environment. A study of heavy metal contamination in waters near a lead mining and milling area in Missouri, however, found large accumulation of lead and zinc in fish, amphibians, reptiles and invertebrates of the downstream aquatic communities (Wixon, 1977). Sunfish and catfish living in stilling ponds and streams immediately below milling sites had accumulations of lead up to 178 and 405 mg/kg respectively, with even higher levels in aquatic invertebrates. Very high levels of zinc were also noted.

In general it appears that, with the exception of mercury, heavy metals are not bioconcentrating in aquatic ecosystems. Fish and other aquatic animals appear to accumulate these metals in rates that depend as much upon their habitat as their diet. Neither the Michigan nor the Wisconsin study found levels of lead, zinc, copper or arsenic that were above the limits for fish flesh used in Canada. These studies suggest that in mining and milling areas, where concentrations in the water or sediments are great, accumulations in the biota can greatly exceed safe limits, contamination of fish by these metals below urban and industrial areas is generally not a threat to human health.

### VIII. Sediment

This section will discuss sources of sediment and how suspended sediment in the main stem is affected by increases in flow. The data were obtained from suspended sediment sampling stations operated by the USGS and the Rock Island District, Corps of Engineers.

\* The relationship between trophic status and mercury accumulation would be more accurately portrayed if age, rather than length was available.



The nature of the impact of suspended and settled solids is generally known but quantifying unacceptable or undesirable levels of suspended sediment is not. EPA's Quality Criteria for Water (1972) gives the following:

Aquatic communities should be protected if the following maximum concentration of suspended solids exist.

High level of protection	25 mg/l
Moderate protection	80 mg/l
Low level of protection	400 mg/l
Very low level of protection over	400 mg/l

The unfortunate uses of the word "maximum" precludes the above from being a practical standard since at times of very high discharge, almost all streams would fall into the lowest category. Figure 15 shows how median suspended sediment levels in the Mississippi at Hannibal vary with flow. Median levels at the lower flows (under 75,000 cfs) are less than 100 mg/l and at high flows (above 200,000 cfs) median suspended sediment levels are between 300-400 mg/l. Maximum values exceed 2,000 mg/l. By the 1972 Criteria, this part of the Mississippi gives a very low level of protection to aquatic communities.

EPA's Quality Criteria for Water (1976) gives the following criterion. "Settleable and suspended solids should not reduce the depth of the compensation point for photosynthetic activity by more than 10 percent from the seasonally established norm for aquatic life." The improvement of this definition over the one given in 1972, although needed, is not readily apparent. Instead of measuring the amount of solids themselves, one must measure the attenuation of light after first having determined, for each season, at what depth net primary production by the phytoplankton community is zero. The practicality of the criterion is further compromised by the fact that organic solids including living plankton, when present in great numbers, increase the attenuation of light and can violate the standard. The fact that sediment, which is recognized as the nation's greatest pollutant by volume, confounds us in des-

cribing at what amount it becomes a pollutant, suggests we have a good deal more to learn about it.

Sediment loads increase dramatically from the GREAT I to the GREAT II segment of the river. Figure 16 presents the suspended sediment load contributions to the Mississippi River at Hannibal, Missouri. The average annual sediment load in the Mississippi at Hannibal is seven and one-half (7.5) times larger than at Dubuque, even though the Mississippi watershed at Hannibal is only twice as large as at Dubuque. Figures 17 and Table 11 show the frequency of various flow regimes and distribution of suspended sediment concentrations within each flow regime in the river at Hannibal, Missouri.

#### IX. Fish Diversity

The Upper Mississippi in the last 100 years has changed from a free flowing river draining a frontier to a series of very long pools subject to much barge traffic and draining large cities and vast areas of intensively cultivated land. These changes have greatly altered the physical and biological character of the river, and the character of the fisheries resources of the river.

The earliest important modification of the river was the construction of the Keokuk Lock and Dam in 1913. This and subsequent dams increased the amount of stilled water at the expense of running water. The benthic habitat of much of the river that had previously been silt-free was now covered with silt. Barnicot (1951) noted the difference in the benthic communities of the Mississippi near Keokuk. On the floor of the Keokuk pool he found mussels, chironomids, Chaoborus, pulmonate snails, small bivalves and several species of leeches. In silt-free areas were found caddisflies, Neuroptera, flatworms, beetle larvae, crayfish, Odonates and leeches. This and subsequent dams on the river have probably been responsible for changes in the distribution of fishes. Coker (1929) believes that interference in the breeding of migratory shad and possibly sturgeon has been caused by the presence of Keokuk Dam acting as a barrier. In the case of the Skipjack Herring, Alosa chrysochloris and the Gizzard Shad, Dorosoma cepedianum, their restriction or reduction in the

FIGURE 1  
THE RELATIONSHIP  
OF SUSPENDED SEDIMENT CONCENTRATION  
AND DISCHARGE IN THE MISSISSIPPI RIVER AT HANNIBAL, MO  
(1967-1973, 1974)

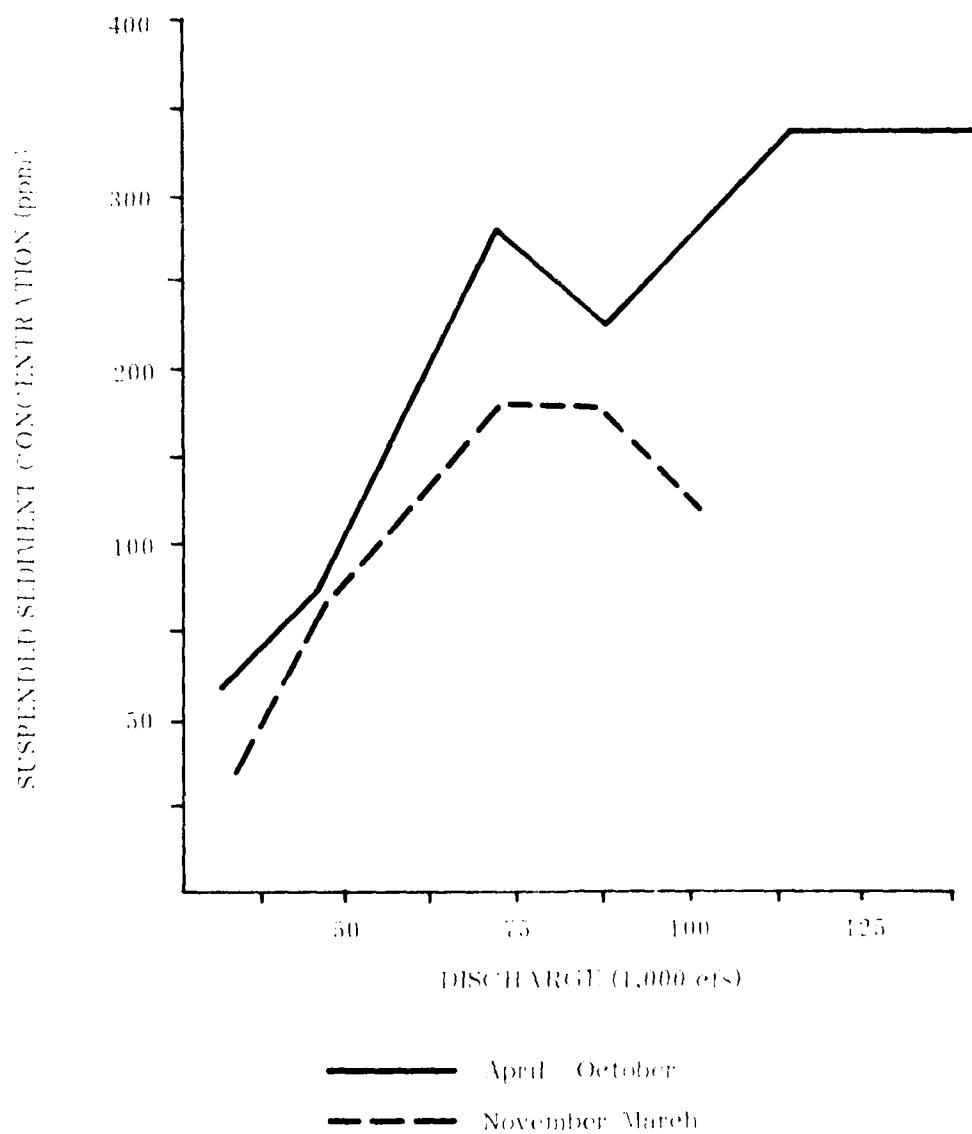
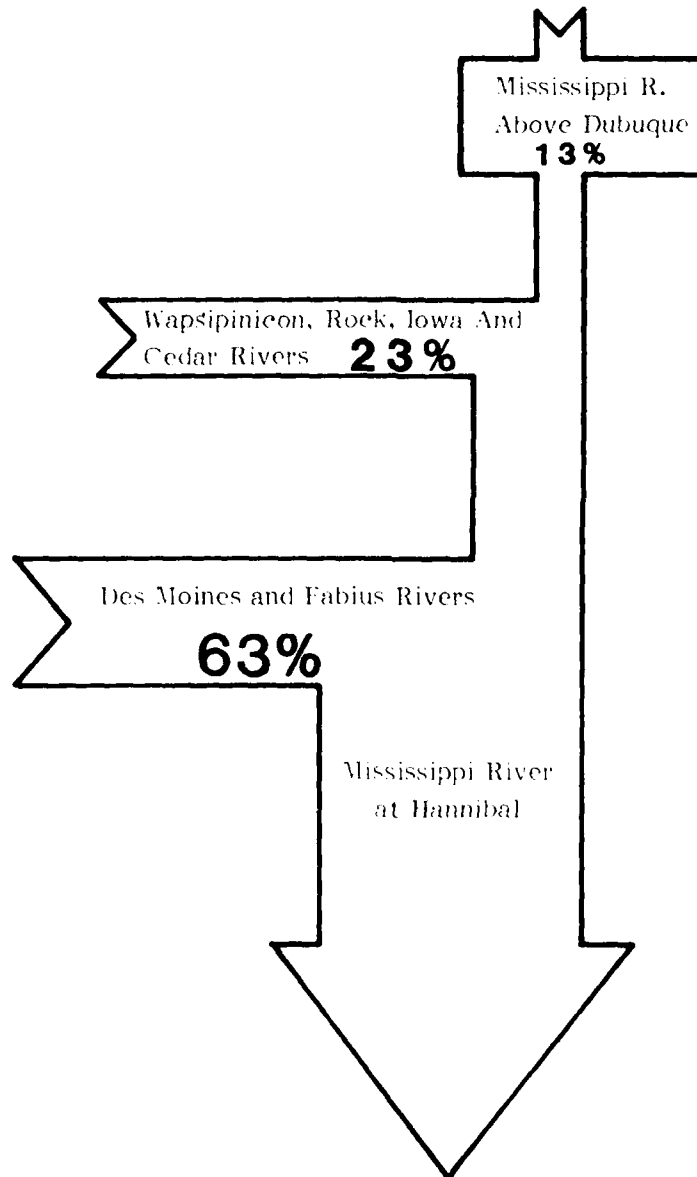


Figure 16  
SUSPENDED SEDIMENT LOAD CONTRIBUTIONS  
TO THE MISSISSIPPI RIVER AT HANNIBAL, MISSOURI  
(1944-1966)



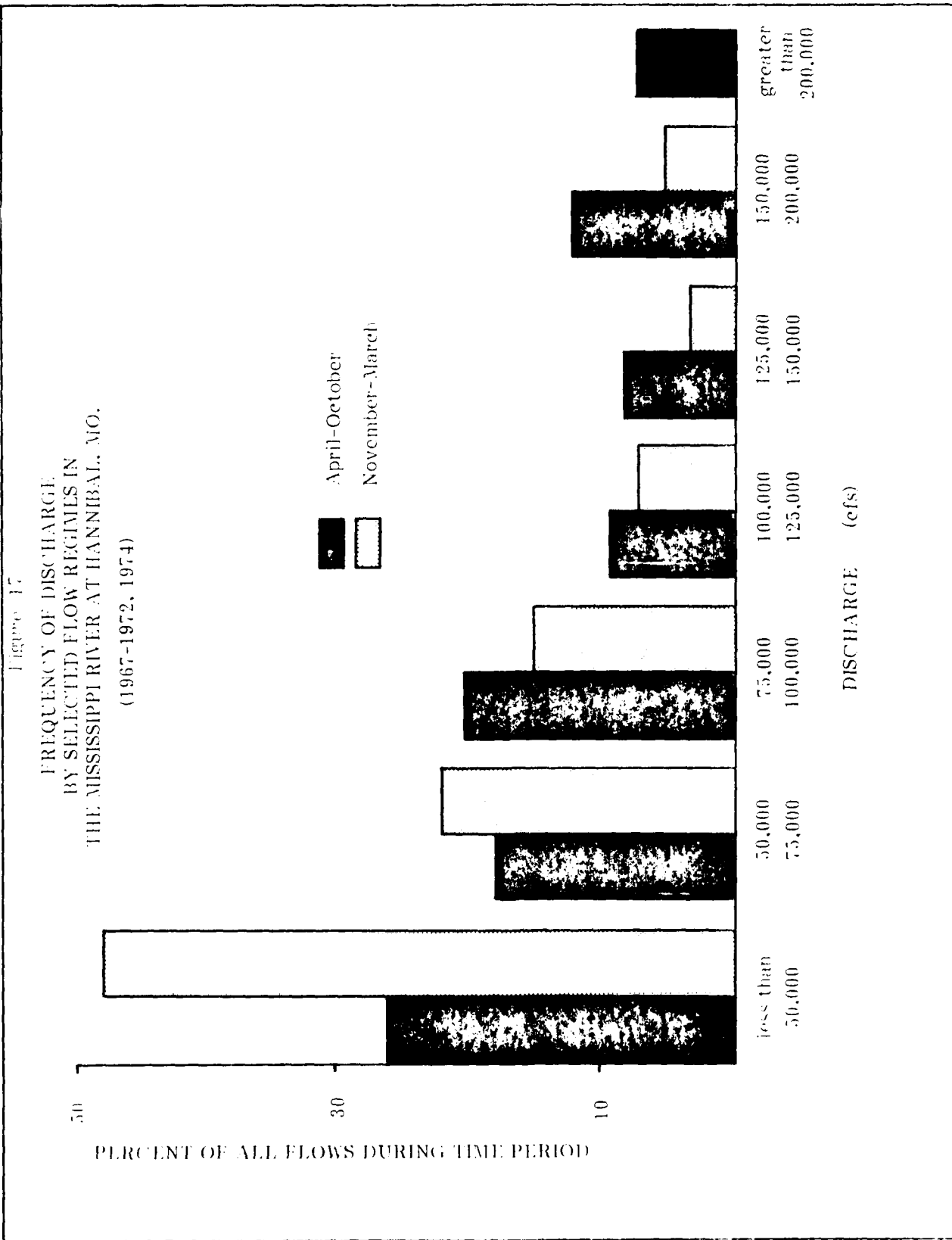


Table 11

DISTRIBUTION OF SUSPENDED SEDIMENT CONCENTRATIONS  
WITHIN SELECTED DISCHARGE RANGES  
(Percent)

April-October

Discharge Range (1000 cfs)	SUSPENDED SEDIMENT CONCENTRATION (PPM)													
	0 25	26 50	51 75	76 100	101 150	151 200	201 250	251 300	301 400	401 500	501 600	601 800	801 1000	1001 1250
0 50	9	37	22	8	10	5	3	1	2	1	2	1	1	1
50 75	4	11	22	14	18	7	8	4	5	2	2	2	1	
75 100		1	5	15	22	12	13	4	8	9	3	4	1	1
100 125	5	4	4	6	9	14	6	14	7	13	6	2	6	2
125 150	3	1	6	2	16	12	12	9	10	7	6	7	5	1
150 200	2	6	8	4	11	8	6	9	12	10	4	6	7	1
200 250	1				15	3	6	6	25	18	1	15	3	1
250 300		3				10	20	10	23	23	7		3	
300 350								20	60				20	

river above Keokuk affects the benthic community since they are host for the larval state of commercially important mussels. Eels, *Anguilla* sp. which are catadromous (migrate to salt water to spawn), have had their distribution, but not their spawning areas reduced.

The change from lotic to lentic habitat has also affected fish distribution. Spawning areas have been severely reduced and fish which normally inhabited the swifter areas of the river have lost living space. Two such species, the Lake Sturgeon, *Acipenser fulvescens* and the Blue Sucker, *Cytleptus elongatus*, have been greatly reduced in number. Barnicoil lists the flooding of the LeClaire and Keokuk Rapids as a major reason for the decline of the Blue Sucker and notes that the preferred food of sturgeon is found over sandy or gravel bottoms and not in silt. He also notes that overfishing has caused a large reduction in sturgeon numbers.

Initially the dams also created a great deal of new fish habitat in the form of sloughs or backwaters which were readily exploited by buffalo fishes and many sport fishes. However, many of the backwaters along with natural floodplain lakes were reclaimed for agricultural land and much of this habitat was lost.

Introduction of the carp, *Cyprinus carpio*, from Asia via Europe prior to 1900 has had a major effect on the relative importance of major fish species of the river. Records of commercial fish catches from the Mississippi River in Illinois and Missouri from 1894, 1899, 1931, and 1946 were compared by Barnicoil (1951). The most significant trend was the increase in the proportion of carp at the expense of the buffalo fish and catfish. In 1894, buffalo fish (including the Quillback) comprised 50 percent of the commercial catch by weight; catfish about 22 percent and carp 4 percent. By 1946, carp was about 47 percent, buffalo fish 21 percent and catfish 14 percent of the commercial catch by weight. During that same period there was a halving in the importance of paddlefish and a threefold decline in the importance of sturgeon. The decline of native fishes as percent of total catch is made all the more significant by the fact that during this period

the total weight of the commercial catch dropped from 6.3 to 2.1 million pounds annually.

Clearly the quality of the Mississippi as fish habitat has been declining. Impoundment, overfishing and introduction of foreign species have all contributed to declines in native fish population.

It is not readily apparent on the Mississippi how instrumental water quality has been in these declines compared to other factors, but information from other streams is available. Several studies have shown significant reduction in fish diversity due to degradation in water quality. Fish declines documented by Lachner (1956) from the Upper Ohio River showed 18 species extirpated and six greatly reduced in numbers. The pollutant was acid mine drainage from the coal mines of western Pennsylvania. Larimore and Smith (1963) found 16 species removed from the fish fauna of Champaign County, Illinois, which is a headwaters area for five streams. The main cause was the change in land use to intensive agriculture during the present century which has modified the aquatic habitat and degraded water quality. Gerking (1945) sampled 10 streams in Indiana which had been sampled 50 years before and found about a 13 percent decline in the number of fish species. All of these studies included a variety of stream sizes and, therefore, are not really comparable to large rivers like the Mississippi which have a distinctive fish fauna. Some data are available, however, for the main stem of larger rivers. Mills (1966) believes that 18 species have been lost from the main stem of the Illinois River which was subject to large amounts of organic pollutants during the 1920s and 1930s, and still receives a large amount of treated effluent, barge traffic and runoff from agricultural land. The main stem of the Missouri, by contrast, has undergone significant channel modification (mostly increasing rather than decreasing the current) but Pflieger (1975) does not list any fish as extirpated and only two species as being greatly reduced in number.

At least two species of fish appear to have been extirpated and seven others greatly reduced in number on the Upper Mississippi. Harlan (1956) noted that the Grass Pickerel,

Esox vermiculatus, was reported to be in the Mississippi above Dubuque, Iowa in 1935, but could no longer be found there. This date corresponds closely to the construction of dams on that area of the river (Lock and Dam #11 was completed in 1937, Lock and Dam #12 and #13 were completed in 1938). Pflieger (1975) noted at least five species of fish in the river above the Missouri which had been greatly reduced in number, and one, the Pallid Shiner, Notropis amnis, which has apparently been extirpated. Impoundment was not the entire problem since the Pallid Shiner also vanished from unimpounded sections of the Mississippi and from free-flowing tributaries. Pflieger believes turbidity and siltation were probably major factors in the disappearance of this species. Of the five species he notes as greatly reduced in number, high turbidity may be important in the decline of the Central Silvery Minnow, Hybognathus nuchalis, the Smallmouth Bass, Micropterus dolomieu, the Blue Catfish, Ictalurus furcatus, the Lake Sturgeon, Acipenser fulvescens, and the Paddlefish, Polyodon spathula have all apparently suffered from habitat modification, and the latter two species, which mature slowly, have been affected by overfishing.

The Upper Mississippi has not experienced the reduction in numbers of fish species as have more polluted rivers such as the Illinois or the Upper Ohio. Turbidity and possibly other water quality problems are indicated as being a problem with three of the species listed in Table 12, and may in fact, be the most important reasons for declines in the two Cyprinids, the Pallid Shiner and the Central Silvery Minnow. The impoundment of the river with the subsequent physical presence of dams and widespread habitat modification appears to be more significant in the declining diversity of the fisheries resource.

#### X. Summary of the Present Status of Water Quality in the Upper Mississippi River

The water quality of the Mississippi reflects her geological, climatological and more recently her agricultural and industrial heritage. Despite urbanization, intensive agriculture and a thriving waterborne commerce, water quality on much of the river has

generally been good. Major reasons for the overall good quality of the river water is the large size of river, hence its large waste dilution and assimilation capacity, and state and federal water clean up programs.

The river is not without water quality problems. Some problems are common to most or all of the river. The most serious, in general, are localized problems below particularly large pollutant sources. These problems usually diminish due to dilution, chemical processes, biological renovation or assimilation. Such health hazards as bacterial contamination, high metals content in the water and a high content of chlorinated hydrocarbons (PCBs, pesticides) in fish occur in certain segments of the river. Table 13 and Figure 18 describe the water quality monitoring network for the Upper Mississippi River Basin. A summary of the extent of various pollutants is given in Table 14.

Iron, manganese and mercury frequently are in violation of water quality standards throughout the length of the river. The iron and manganese standards are aesthetic rather than health standards and much of the iron and manganese found in the water is the result of natural weathering. The frequency of high levels of iron in the river increases below the Illinois River, probably in response to Illinois River water and point sources in the St. Louis area. The mercury standard is violated frequently because the allowable amount of mercury in water is very small. Several researchers have reported high levels in fish from waters not affected by other than natural mercury sources. Therefore, weathering and soil erosion may account for the extensiveness of the mercury problem. Although the water standard has been exceeded, the amount in Mississippi River fish flesh appears to be at or near what has been reported as background levels. The drinking water standard for mercury has been exceeded in the Mississippi in the St. Louis area.

Dieldrin is a chlorinated hydrocarbon insecticide and breakdown product of another insecticide, Aldrin. These chemicals have been extensively used on corn, but due to Dieldrin's persistence in the environment, neither pesticide has been registered for

Table 12

Fish Species Known to be Extirpated or Greatly Reduced  
in Number on the Upper Mississippi River

Species	Cause of Decline			
	Habitat Modification	Water Quality	Over- Fishing	Physical Presence of Dams
1. Chain Pickerel <u>Esox vermiculatus</u>	X			
2. Blue Sucker <u>Cycoreptus elongatus</u>	X			
3. Paddlefish <u>Polyodon spathula</u>	X		X	
4. Lake Sturgeon <u>Acipenser fulvescens</u>	X	X	X	X
5. Smallmouth Bass <u>Micropterus dolomieu</u>	X			
6. Pallid Shiner <u>Notropis amnis</u>	X	X		
7. Central Silvery Minnow <u>Hybognathus nichalis</u>		X		
8. Blue Catfish <u>Ictalurus furcatus</u>	X			
9. Skipjack Herring <u>Alosa chrysochloris</u>				X

Table 13  
Water Quality Monitoring Network for the Upper Mississippi River Basin

Location	Sampling Agency	River Mile	Temperature	pH	DO	Conductivity	Alkalinity	Hardness	Total Solids	Vol. Susp. Solids	BOD	COD	Organic N	NH <sub>3</sub> -N	NO <sub>2</sub> -NO <sub>3</sub> -N	Total P	Soluble P	TOC	TC	IS	AS	CD	Cr	Cu	Tc	Pb	Mn	Ni	Ag	Hg	Zn	Major Ions	PCBs	Pesticides	Fish Flesh	Algae	Susp. Sediment			
St. Louis, MO	WDR	814	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	
St. Louis, MO	USGS	797	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	
Rock River, WI	WDR	791	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	
Rock River, WI	WDR	767	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	
Rock River, WI	WDR	752	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	
Rock River, WI	USGS	726	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	
Rock River, WI	WDR	657	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	
Rock River, WI	WDR	630	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	
Rock River, WI	USGS	635	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	
Rock River, WI	USGS	520	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	
Rock River, WI	WDR	526	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	
Rock River, WI	WDR	484	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	
Rock River, WI	WDR	384	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
Rock River, WI	WDR	364	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
Rock River, WI	USGS	364	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	
Rock River, WI	WDR	241	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	
Rock River, WI	USGS	203	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	
Rock River, WI	WDR	203	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	
Rock River, WI	USGS	190	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	
Rock River, WI	WDR	132	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	
Rock River, WI	WDR	100	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	
Rock River, WI	USGS	44	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	
Rock River, WI	WDR	5	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	
St. Louis, MO	USGS	44	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	
St. Louis, MO	WDR	5	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	

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U.S. Geological Survey

USGS - U. S. Geologic Survey  
WDR - Wisconsin Department of Natural Resources

Figure 18  
LOCATIONS OF PRESENT WATER  
QUALITY SAMPLING STATIONS ON THE UPPER  
MISSISSIPPI RIVER

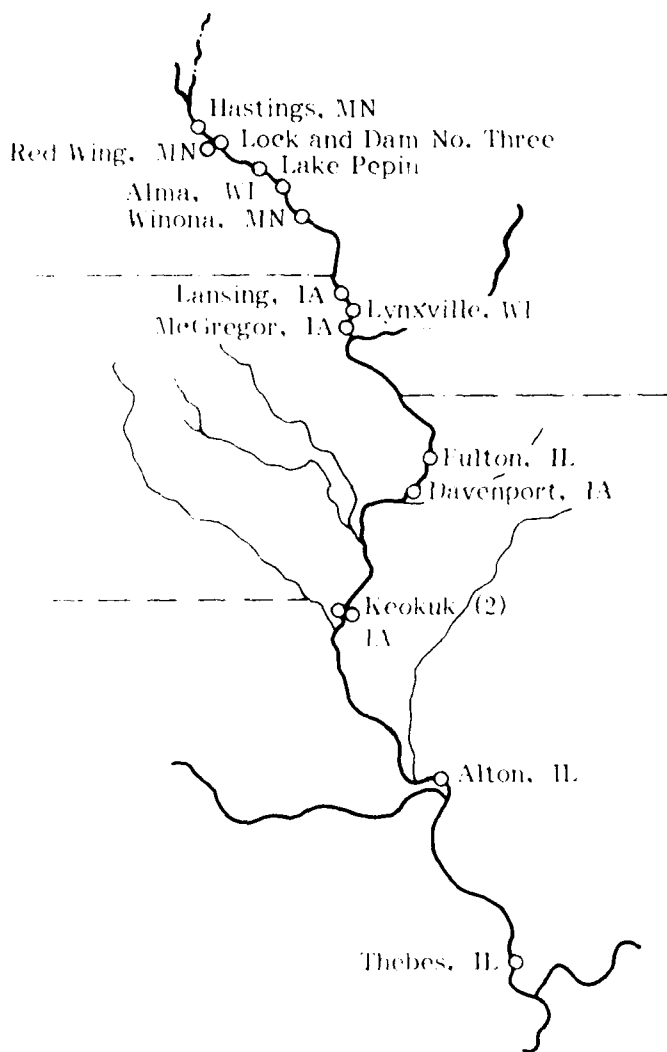


Table 14

THE EXTENT OF VARIOUS WATER QUALITY STANDARDS VIOLATIONS  
IN THE UPPER MISSISSIPPI RIVER

		Drinking Water Standard	Protection of Aquatic Life Standard	Fish Flesh Standard	Whole Body Water Contact Standard
Entire Length of River	-	Iron (1)* Manganese (1)	Mercury (1) Dieldrin (4) Sediment (4) Copper (2)		Fecal Coliform (3) from St. Louis area.
	100 -	Lead (2)	Other Pesticides (4)	PCBs (2)	
	10 -	Mercury (2)	Dissolved Oxygen (2,3)		Fecal Coliform (3) from Quad Cities
	1 -		Heat (2)	Dieldrin (4)	
Extent of Standards Violation in Miles					

\*(Major Sources)

1. Natural Weathering, soil erosion
2. Industrial, commercial waste
3. Domestic waste
4. Agricultural non-point

agricultural use. Dieldrin has a very low solubility in water but residues in the soil and in stream sediments act as a reservoir to renew the amount in the water. The lack of a great deal of intensive agriculture in the northern part of the Upper Mississippi Basin is the only factor which precludes Dieldrin from being a basin-wide problem. It is often found in detectable levels from the Quad Cities Area to Cairo, Illinois, and is found most frequently in the area of southern Iowa where the major tributaries draining the croplands of that state empty into the Mississippi. Other pesticides are detected most frequently in the same area, but they are not detected as often as Dieldrin in any part of the river.

Violations of the copper standard for aquatic life occur from Dubuque to Burlington, Iowa, and from Alton to Cairo, Illinois. Various forms of copper exist in water and all have different toxicities. The overall toxicity of copper is reduced by the bicarbonate nature of the river. The importance of copper as a toxic substance in the Mississippi is not known.

Although a suspended sediment standard of practical value has yet to be developed, the sediment load of the Upper Mississippi changes so dramatically that suspended sediment can be called a pollutant in the river from southern Iowa to Cairo, Illinois. The Mississippi opposite Minnesota, Wisconsin and northern Iowa is clear for a large river. Sediment loads from tributaries in the GREAT II segment increase the suspended sediment load of Mississippi by approximately seven hundred percent. Much of this increase is due to natural causes. Studies of fish distribution show that natural turbidity levels in the Missouri were so much higher than in the Mississippi above the Missouri that their confluence marked the southern limit of several species distributions in the Mississippi. Conversely, some fish which are adapted to more turbid waters had distributions that included the Missouri and the Mississippi below the Missouri, but not the Mississippi above the Missouri because of the clear water.

The primary drinking water standard (health) and the aquatic life standard for lead

have been violated in the Mississippi between Dubuque and Burlington. Industrial discharges in that area are considered to be a primary source and erosion and sedimentation are probably responsible for the continuation of the problem below Burlington.

Analyses of bacterial contamination in the river, as measured by fecal coliform concentrations, show high levels below the Quad Cities area which greatly interfere with fish sales. Below the St. Louis area, high fecal coliform counts are found for the next 200 downstream miles of the Upper Mississippi. Since the State of Illinois is the only Mississippi tributary general area where water body contact recreation is allowed, water skiers, the above mentioned violations are in violation of established water quality standards. Most of the remaining segment of the river contains fecal coliform concentrations near the allowable limit.

Polyethylene glycol (PEG) is found in the Upper Mississippi pose a greater threat to contamination of the food chain than to shellfish, than to the general public drinking water. PCBs have low solubility in water but a great affinity for fine suspended or bottom sediments within the river. The Quiescent segments of the Mississippi are major sources of PCBs have sediment laden fish with the highest levels of PCBs. Levels of the Mississippi from the Twin Cities region and including Lake Pepin contain fish which exceed the FDA 2 mg/kg standard for PCBs. Increases in PCB contamination at the St. Louis St. Louis have been documented but no levels in excess of the FDA standard have been measured.

Dissolved oxygen concentrations below the 5 mg/l level have been recorded at several locations on the Upper Mississippi but the problem appears to be more frequent and more severe in the Alton pool and in the segment of the river below St. Louis. USGS has recorded dissolved oxygen levels as low as 3.5 mg/l in the St. Louis area and 2.4 mg/l near Cape Girardeau, Missouri. It is the general consensus of the fisheries biologist and researchers that a prolonged period of these levels can cause stress or even mortality in some species of fish inhabiting the river.

Large power plants which rely on river water for cooling are responsible for the introduction of great amounts of heat into the river. In most instances these plumes of heated water occupy only a fraction of the channel width and the length of the plume which is 5° F. above ambient temperature is less than one mile in length. The major

concerns about heat discharges to the river are the effects on ichthyoplankton (fish larvae) and adult fishes, both of which are very sensitive and can be killed by high temperatures or rapid temperature changes. A summary of these water quality problems and resultant recommendations of the GREAT II Water Quality Work Group are given in Table 15.

Table 15

WATER QUALITY RELATED PROBLEMS ON THE UPPER  
MISSISSIPPI RIVER AND GREAT H WQWG  
RECOMMENDATIONS

PROBLEMS

RECOMMENDATIONS

High levels of Pesticides in water and fish.

High levels of PCBs in fish.

High levels of certain heavy metals (Pb, Cu, Fe, Mn, Hg) in water.

Large point source discharges increasing nutrient levels in the river.

Increasing oxygen demand in a downstream direction, possible oxygen sags below large urban areas.

High fecal coliform levels below large urban areas.

Inadequate sampling to determine magnitude of water quality impacts of a large urban area on the river.

Different use classifications, and effluent guidelines in different states.

Differences in data collection format for thermal studies. Inadequate studies for some large power plants.

Improve industrial pretreatment programs

Establish a group of W.Q. monitoring stations to measure W.Q. impacts of a large urban area on the river.

Compatible W.Q. management regs. and guidelines should be developed.

Standardize thermal monitoring report.

## GLOSSARY

Adsorption--adhesion of molecules to a surface

Atmosphere--the prevailing or surrounding condition

BOD--Biochemical Oxygen demand

COD--Chemical Oxygen demand

Desorption--removal of molecules from a surface

Elutriate--the liquid that remains after a sediment sample is mixed in water, then filtered.

Eutrophication--a process of increasing nutrient levels and aquatic plant growth in lakes or streams

Hydrograph--a graph which shows changes in discharge over time

Lentic--a still water environment (lake, pond or pool)

Lotic--a moving water environment (stream or river)

NASQAN--a nation-wide network of water quality monitoring stations maintained by the U.S. Geologic Survey.

NPDES--a national system of wastewater discharge permits

Suspended Solids--a measure of the amount of solids which are in the water

Thermal Plume--a discrete three-dimensional area of heated water within a river, lake, etc.

Turbidity--a measure of the ability of light to penetrate water

## BIBLIOGRAPHY

- Armstrong, E.A.J. and Hamilton, A.L., 1973, "Pathways of Mercury in a Polluted Northwestern Ontario Lake," Chapter 5, in "Trace Metals and Metal-Organic Interactions in Natural Waters," P.C. Singer (Ed.) Ann Arbor Science, Ann Arbor, Michigan.
- Barnicot, P.G. and Starrett, W.C., 1951, "Fishes of the Mississippi River," Illinois Nat. Hist. Surv. Bull. 25:5, 266-350.
- Bowie, J.E., 1971, Temperature of Missouri Streams, USGS, Water Resources Division, Rolla, Missouri.
- Choi, W. and K.Y. Chen, "Association of Chlorinated Hydrocarbons with Fine Particles and Humic Substances in Near Shore Surficial Sediments," ENVIR. SOC. TECH. 10:8:782-786.
- Coker, R.E., 1929, "Keokuk Dam and the Fisheries of the Upper Mississippi River," Bull. Bur. Fish Wash. 45:87-139.
- Dorris, T.C. and Copeland, B.J., 1962, "Limnology of the Middle Mississippi: IV Physical and Chemical Limnology of River and Chute," LIMNOL. Oceanogr. 8:79-88.
- Gerking, S.D., 1945, "The Distribution of Fishes in Indiana," INVEST. OF IND. LAKES AND STREAMS. 3:1-137.
- GREAT I, Water Quality Work Group, 1978, "A Pilot Study on Effects of Hydraulic Dredging and Disposal on Water Quality of the Upper Mississippi River (July 1976)."
- Grimes, D.J., 1975, "Release of Sediment-Bound Fecal Coliforms by Dredging," APPL. MICROBIOL. 29:109-111.
- Harlan, J.R. & Speaker, E.B., 1956, Iowa Fish and Fishing, Iowa Conservation Commission, Des Moines, Iowa.
- Harvey, D.J. and W.G. Steinhauer, 1976, "Transport Pathways of Polychlorinated Biphenyls in Atlantic Water," JOUR. MARINE RES. 34:561-575.
- Hora, M.E. (Ed.), 1976, Polychlorinated Biphenyls (PCBs) in the Upper Mississippi River Basin, Minn.-Wisc. PCB Interagency Task Force
- Hynes, H.B.N., 1970, The Ecology of Running Waters, University of Toronto Press, Toronto, Canada and Buffalo, N.Y.
- Illinois EPA, effluent monitoring data, unpublished, personal communication, Springfield, Illinois.
- Illinois EPA, Water quality data for Mississippi River from 1972 through 1977, unpublished data, personal communication.
- Illinois EPA, 1976, Water Quality Management Basin Plan, Phase 1; (South, South Central, North Central and North Mississippi River Basin volumes), Springfield, Illinois.

Iowa Conservation Commission, 1976, Commercial Fisheries Investigations Annual Performance Reports, Project No. 2-255-R, "Northern Pike Investigation (Segment 2) July 1, 1975-June 30, 1976." Des Moines, Iowa.

Iowa Division of Environmental Quality; effluent monitoring data and in-stream pesticide concentration data, unpublished, personal communication, Des Moines, Iowa.

Iowa Division of Environmental Quality, 1976, Iowa Water Quality Management Plan; (Northeastern Iowa, Cedar-Iowa, Skunk and Des Moines Basin volumes.) Des Moines, Iowa.

Kansas Forestry, Fish and Game Commission, 1972, "Pesticide Residue in Kansas Streams," Dingell-Johnson Project F-15-R, Job No. K-1-1.

Lachner, E., 1956, "The Changing Fish Fauna of the Upper Ohio Basin," Man and the Waters of the Upper Ohio Basin, Pittsburgh University, Pittsburgh, Pennsylvania.

Larimore, R.W. and Smith, P.W., 1963, "The Fishes of Champaign County, Illinois." Ill. Nat. Hist. Surv. Bull. 28:2, 299-382.

Lorenz, T.F., 1976, Summary Report of the Occurrence of PCB Fish Flesh Contamination in the Rivers and Streams of Region VII. U.S. EPA, Region VII, Surveillance and Analysis Division, Kansas City, Kansas.

Mackay, D. and A.W. Wolkoff, 1973, "Rate of evaporation of low-solubility contaminants from water bodies to atmosphere." ENVIRON. SCI. TECH. 7:611-614.

McKee, J.E. and Wolf, H.W., 1963, Water Quality Criteria. California Water Resources Control, Sacramento, California, 547 pp.

Michigan Department of Natural Resources, 1972, Heavy Metals in the Surface Waters, Sediments and Fish in Michigan, Lansing, Michigan.

Mills, H.B. et al, 1966, "Man's Effect on the Fish and Wildlife of the Illinois River." ILL. NAT. HIST. SURV. BIOL. NOTES No. 57, Urbana, Illinois.

Missouri Department of Conservation, unpublished data, personal communication.

Missouri Department of Natural Resources; effluent monitoring data, Jefferson City, Missouri.

Missouri Department of Natural Resources; thermal monitoring reports from files, unpublished. Jefferson City, Missouri.

Missouri Department of Natural Resources; Water Quality Management Basin Plans (Des Moines Salt, Upper Mississippi-Meramec River Basin volumes). Jefferson City, Missouri.

Pflieger, W., 1975, The Fishes of Missouri, Missouri Department of Conservation, Jefferson City, Missouri.

Ruttner, Franz, 1953, Fundamentals of Limnology, University of Toronto Press, Toronto, Canada and Buffalo, New York.

Schafer, M.L., et al. 1967, "Pesticides in Drinking Waters from the Mississippi and Missouri Rivers," ENVIR. SCI. & TECH. 3:12, 1261-1269.

Skeffy, T.B., 1977, 1977 Status Report on the PCB Problem in Wisconsin, Wisconsin Department of Natural Resources, Madison, Wisc.

U.S. Fish and Wildlife Service, 1978, Dynamics of PCBs in the Upper Mississippi River, Vols. I-II. Columbia, Natl. Fishery Res. Lab., Columbia, Missouri.

U.S. EPA, 1972, Quality Criteria for Water, Washington D.C.

U.S. EPA, 1976, Quality Criteria for Water, Washington, D.C.

U.S. EPA, Region V, thermal monitoring reports from files, unpublished personal communication, Chicago, Illinois.

U.S. EPA, Region VII, thermal monitoring reports from files, unpublished, personal communication, Kansas City, Missouri.

United States Geological Survey, Water Resources Data, one volume published annually for each state.

Wetzel, Robert. 1975, Limnology, W.B. Saunders Company, Philadelphia, London, Toronto.

Wisconsin Department of Natural Resources, effluent monitoring data, unpublished, personal communication.

Wisconsin Department of Natural Resources, 1972, Mercury Levels in Wisconsin Fish and Wildlife, Tech. Bull. No. 52, Madison, Wisconsin.

Wisconsin Department of Natural Resources, 1977, Wisconsin Water Quality Program Basin Report (Grant-Platte River Basin volume).

Wixson, B.G. (Ed.), 1977, Missouri Lead Study, Interdisciplinary Lead Study Team, University of Missouri, Rolla, Missouri.

B. MINUTES OF  
WATER QUALITY WORK GROUP MEETINGS

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

DATE: November 23, 1977

SUBJECT: GREAT II Water Quality Work Group Meeting

FROM: *Robert J. Koke*  
Robert J. Koke, Chairman  
Water Quality Work Group

TO: Work Group Members

A meeting of the GREAT II Water Quality Work Group was held at 1 p.m., at the Rock Island District Corps of Engineers Office.

Persons in Attendance

Joh-Eric T. Stenson	U.S. EPA, Chicago
Robert J. Koke	" " , Kansas City
Bill Koellner	Corps of Engineers, Rock Island
Mike Werner	" " " " "
George Johnson	" " " " "
Robert J. Whiting	" " " St. Paul
Victor Crivello	Illinois EPA Coordinator
Wendy Thur	Public Participation Coordinator
Steve Waters	Iowa Conservation Commission
Rick Breitenbach	U.S. Fish and Wildlife Service
Tom Bainbridge	Wisconsin Dept. of Natural Resources
Jim Holman	Missouri " " " " "
V. Ramaiah	" " " " "

Accomplishments

Bob Whiting, St. Paul District and Cochairman of the GREAT I Water Quality Work Group, provided a status report on what his group is doing.

1. GREAT I has studied the water quality effects of the first tow through Lake Pepin.
2. They have performed analysis of bed sediment at every other mile of the Mississippi River.
3. They have monitored the turbidity of the plume from a claybell duct disposal operation.

The GREAT I Work Group has found it essential to have a full-time chairman or staff member.

The work group discussed and approved a Plan of Study to work with the sediment erosion committee on analysis of bed sediment and suspended sediment on tributary streams. No member of the work group opposed this project.

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The work group discussed and rejected the Internal Overview Committee's suggestion that the work group use the funds available for FY-78 to hire a full-time chairman. The group believed that the money is best spent on a study of sediment which may generate the need for a full-time chairman or staff member next year.

The state members were asked if their agency would assume chairmanship of the work group, but no one was willing to accept it.

The Corps of Engineers discussed their water quality sampling program.

Enclosure 1

Minutes of the Last WQWG Meeting Held in Jefferson City on January 12, 1978

The following persons attended the meeting:

V. Ramaiah, Mo. Department of Natural Resources, Member  
Tom Bainbridge, Wisconsin Department of Natural Resources, Member  
Bob Koke, U.S. Environmental Protection Agency, Region VII, Member  
Dave Stoltenberg, U.S. Environmental Protection Agency, Region V, Member  
Jim Holman, Mo. Department of Natural Resources, Observer  
Chris Reck, Mo. Department of Natural Resources, Observer

A. Approval of Missouri's Chairmanship:

The WQWG elected me as the chairman and approved the budget I had submitted, by a voice vote. A copy of the budget proposal was sent to you earlier by Bob Koke.

B. Status Report on Chairmanship:

Bob Koke also submitted the budget proposal to the Plan Formulation Work Group (PFWG) and GREAT II Team. Approval of the PFWG and the Team is anticipated on January 19th and January 27th respectively.

C. Chairman's Responsibilities:

- (1) The State of Missouri will expend every effort toward the completion of the Water Quality Appendix within the constraints of the approved budget.
- (2) All decisions to be taken only by general consensus. For this purpose the members are requested to provide sufficient timely input to a more effective decision making process.
- (3) As much of business as possible will be negotiated over the phone. However, major decisions will be taken only in face to face meetings.
- (4) Future meetings are to be held in more convenient places such as St. Louis and Kansas City.

D. Discussion of the minutes of the last meeting:

Due to the election of a new chairman, discussion on this topic was considered unnecessary. For the future, it is agreed that the discussion will be taped from which a summary will be prepared as the official minutes.

E. Identification of Sources of Pollution:

Generally it was agreed that we should list as many problems as possible and complete this task before February 1, 1978. The following sources of pollution were mentioned: (1) pollution from GREAT I area, (2) upland erosion, (3) stream bank erosion, (4) dredging, (5) disposal of dredged material, (6) movement of rivercrafts, (7) point source discharges,

(8) accidental spills, (9) urban runoff and (10) beaches. Members were requested to propose changes as soon as possible.

F. Interfacing with Other Work Groups:

Due to the complexity of water pollution control, it was suggested that the WQWG take the leadership role in areas where no other entity has programs for pollution control and be actively involved with agencies/work groups who have the authority to develop control programs so that the concerns of the WQWG is sufficiently represented.

G. Detailed Studies:

It was agreed that each member should prepare a separate list and mail to all other members by February 15. Then sometime in the first week of March, we will meet in St. Louis to finalize the list. The Plan of Action which is due for submission on April 1 will be written based on this list. It was also suggested that the subject of Detail Studies be restricted to Level I involvement.

There was a discussion on Literature Research. As the publication of water pollution related activities is too voluminous in the recent year, it was suggested that the scope may have to be restricted. It was also suggested to use the output of GREAT I's WQWG and the new employee to be hired by Missouri to the greatest possible extent; that way we can avoid duplication of effort and utilize the talents and aspirations of the new employee.

FROM: V. Ramaiah "Ram", Chairman, WQWG of the GREAT II  
TO: Members of WQWG, PFWG and GREAT II Team  
SUBJECT: Minutes of the WQWG Meeting, held in St. Louis on March 1, 1978

1. The meeting was attended by:

Rick Breitenbach	U.S. Fish & Wildlife Service
Mike Werner	Corps of Engineers, Rock Island
Rich Greenwood	U.S. Fish & Wildlife Service
Gene Degenhardt	Corps of Engineers, St. Louis
Bill Koellner	Corps of Engineers, Rock Island
Dave Stoltenberg	U.S. E.P.A., Chicago
Tom Bainbridge	Wisconsin DNR
Bob Koke	U.S. E.P.A., Kansas City
Mark Ackelson	Iowa Conservation Commission
V. Ramaiah	Mo. Dept. of Natural Resources

2. Location. It was decided to hold future meetings in Rock Island and Bill Koellner will make the necessary arrangements for a conference room.
3. The Iowa DEQ is not likely to attend the meetings as they have assigned a low priority for the GREAT River Study. However, Mr. Obr should be kept abreast of the developments.

I. Minutes of last meeting: (no discussion).

II. Status Report:

I have submitted to the Corps a contract proposal. It will be 6 to 8 weeks before the Corps can finalize the contract and it will be 10 to 12 weeks before a full time employee is hired. This employee will be a Water Quality Specialist III and this designation requires MS plus three years work experience. This individual must have strong research aptitude as at least part of his time is likely to be used for literature research.

VII. Efforts of WQWG of GREAT I.

- A. Pilot Study: A copy of the summary section of this preliminary report was distributed and the entire report is to be mailed later. As this report was received only two days before the meeting, I did not have the time to study it thoroughly. So it was agreed to review this report and modelling procedures before its applicability to GREAT II is determined. The idea is to avoid duplicating GREAT I's effort and check the applicability of modelling to predict dredging disposal and tow traffic. By the 17th of March, I will be discussing these elements with Mike Werner and Tom Bainbridge and establish our objectives and possibly the procedure before the next meeting.

#### IV. Definition of the Approach:

Basically as defined in the memo of January 17 was accepted. It was decided to concentrate on Level I projects and in Level II projects involving the work of other work groups of GREAT II. In the case of projects requiring Level II coordination, for which control measures are being developed by agencies other than GREAT river study such as the States 208 planning process and project requiring Level III coordination will be temporarily deferred to the latter part of FY 79. At that point our involvement will be restricted to policy matters.

The critical time element was discussed. It will be necessary to complete the proposal before March 15 so that the PEWG will have sufficient time to study the proposal and act upon it in the next meeting.

Level I projects will receive the highest priority. However, there are a few proposals for detailed studies outside the navigational use related problems. These studies will not be dropped from our listing, but given a lower priority than those studies proposed directly to evaluate the problems related to navigational use.

Some of the studies, although of importance for total resource management, are considered beyond the scope of GREAT due to their complexity, cost and duration. A case in point is the proposed Toxic Substance Control Study and Water Quality Modelling of the entire stretch of the Mississippi River. These studies will be listed for 'long term planning' and other agencies such as the UMRBC will be recommended to undertake it. It is also decided that the WQWG must be dealing with the technical studies of importance to channel maintenance and not a review group for other agencies.

#### V. Proposed Topics:

##### A. Navigational Use Related Problems:

It was decided to defer any further discussion on this topic to the next meeting. In that period, we will be studying the recent report of the WQWG of GREAT I titled, "A Pilot Study on Effects of Hydraulic Dredging and Disposal on Water Quality of the Upper Mississippi River", and mathematical modelling procedures to predict the water quality impact of dredging, disposal and tow traffic. If at all possible, we will try to combine the two, namely the in-stream sampling and modelling to obtain more information than possible from either of them individually.

It was suggested that instead of deferring a decision, the AGWG prepare a policy statement requiring an in-depth study of future dredging. After further discussion, this idea was dropped. The recreational boating related problem is suggested to be included as an item for study.

##### B. Base Information:

1. Literature Research: It was agreed to be listed but given low priority. The members felt that it is strictly a level 6 study and instructed me to inform the PEWG to take necessary action for Level 6 program to undertake the responsibility.

2. Water Quality Assessment: The WC approved this study with an estimated cost of \$2500 and instructed me to prepare the proposal of work by March 15 to be submitted to the DEQ, and the Department of Natural Resources. It is expected that the study will be completed by the end of 1979 or early 1980.
3. Mapping: The representatives of the state will prepare a list of point source discharges in their state, that enter the Mississippi River directly or impacts its water quality. This list will include the name, location and NPDES permit. Bill Koellner will prepare a map of the river at the next meeting for selecting the appropriate map. Then the State of Missouri will undertake the responsibility of plotting these points. The task will be undertaken in the latter part of 1979 or early 1980.

C. Other Water Use Problems:

1. Toxic Substance Study. This will be one of the subjects for long term planning. There will be no funding request for this study, but it will be included in the final report with a series of studies so that some other group such as UNKBC can develop programs for abatement.
2. Keokuk Pool: Agreed to be included in the listing, but with lower priority. (Subsequently, I talked with Dr. Arthur G. Guntz, State University of Iowa. He thought he might be able to come up with a proposal for Keokuk Pool).
3. Modeling: This item is also agreed to be included for long term planning without any funding request from GEFV II. Bill Koellner will be contacting Ken Thornton of the WES for more information on their Eco-Model. (Subsequently, Dr. Arthur G. Guntz, State University of Iowa, his office will be submitting to us a revised proposal with some figures).
4. Sediment Analysis: It was decided to proceed with the study of analyzing the tributary stream samples, the CFW and the main river collect. I will be contacting Golo Wirth of the DEQ for more information in detail. I will also be choosing the station that the samples will be by Mr. Dennis Miller.
5. Corps Monitoring Need: Koellner presented their perspective on the analysis program for the future.
6. Recreational Boating. This is to be considered as a separate item with lower priority than navigational related problems.
7. Breitenbach proposed a philosophical concept of growth vs. pollution. It is agreed to take up this matter at a later time.

## VI. Prioritization.

After taking the priority of each member, the overall priority is determined as follows:

1. Navigational Use Related Problems.
2. Water Quality Assessment.
3. Sediment Analysis.
4. Fish and Pool Study.
5. Recreational Boating.
6. Literature Research.

In addition, three items proposed for long term planning are:

1. Technical Control Study.
2. Study of the Mississippi River.
3. Bibliography consideration of current V. A. Activities.

MINUTES OF THE WATER QUALITY WORK GROUP MEETING

Time/Date: 10:00 a.m., June 28, 1978

Place: Clock Tower Building, Rock Island, Illinois

The following persons were in attendance at the meeting:

V. Kamath	Missouri Department of Natural Resources
Tom A. Kowalew	Wisconsin Department of Natural Resources
George E. Johnson	COE, Water Quality Coordinator
Bryan J. Goodrum	COE, Hydrology Branch
Kath A. Andrews	COE, Hydrology Branch
Bill Koellner	COE, Hydrology Branch
Jerry Schmoor	University of Iowa, Environmental Institute
Larry Slack	USGS - Iowa City
Rich Greenwood	U.S. Fish & Wildlife Service
David Stoltenberg	U.S. F.P.A. - Region V

### 1. Discussion of the Proposed Lab Simulation Study:

Several questions pertaining to the study were raised and answered satisfactorily. A motion from Bill L. Miller for the approval was seconded by me and approved by the Earl Greenfield. Wisconsin abstaining.

Bill Fiedler indicated that the Corps is working with the EPA on July 6, 1978 to determine the monitoring needs for dredging disposal operations and requested a review of their proposal, Enclosure 3. The Work Group recommended to interface this program with our efforts. In addition the following changes in parameters for analysis were recommended: drop Phosphorus and PCB; add Cyanide and Chromium (coming from Total Phosphorus to Orthophosphate); under Chlorine add a split test for Atrazine, DDE-Dieldrin series and PCB. Upon receipt of a report which was accepted by David St. Hienberg, the Work Group will be reconstituted and adapted the modified procedure. The Work Group will be attending this meeting representing the Work Group.

the 1990s, the number of people in the world who are illiterate has increased from 1.2 billion to 1.5 billion. The number of illiterate people in the world is projected to reach 1.7 billion by the year 2015. The number of illiterate people in the world is projected to reach 1.7 billion by the year 2015.

1. The first step is to identify the problem. In this case, the problem is that the company is not meeting its sales targets. The second step is to analyze the data. The third step is to develop a plan. The fourth step is to implement the plan. The fifth step is to evaluate the results.

3. Literature Research:

The Work Group decided to postpone any effort in this area till the output from Level B become available.

4. Maps for Point Source Discharges:

The Work Group agreed to my suggestion that the maps be prepared as part of the final report incorporating pollution source, such as point source discharges, storage tanks, barge terminals and other potential sources for toxic substances. The representatives of the states are to furnish me with a list, updated as of July 1, 1979, and consisting of pollution sources including such information as name of the discharger, NPDES permit number, volume of discharge, type of pollutants, and location. This information will be included as a table in the Water Quality Appendix and the location mapped with proper reference in the table. However, Rich Greenwood suggested that the interim report due for completion in September '78, should contain a table giving the pollution sources. The Work Group agreed with him.

5. Others:

a. On Site Inspection Team: Bill Koelner indicated that the On Site Inspection Team does not have anybody representing the interests of the WGLL. At his suggestion the Work Group requested the WGLL to contact the U.S. EPA, Wisconsin DNR, Iowa DEQ, Illinois EPA and Minnesota DNR and make the necessary arrangements for due representation in the On Site Inspection Team.

b. Frequency of Meetings: Ted Lovejoy suggested that the Work Group meet at regular intervals. However, in view of rather limited time to transact, the Work Group agreed to the following arrangement; regular meetings are not necessary; the chairman to send a monthly report to the members incorporating the transactions of PFWG, any development in the fundal studies and other matters of interest; at any time members can request a meeting, if there is any important matter to transact.



## Great River Environmental Action Team

FEDERAL BUILDING, ROOM 507 • FORT BELLEVILLE • ILLINOIS 62204 • PHONE (314) 517-1100 • FAX (314) 517-1101

John C. Ford, Chairman, Water Quality Work Group, 90 Alton Road,  
P.O. Box 1304, Jefferson City, Missouri 65167, (314) 763-1100

September 19, 1980

To: Water Quality Work Group

From: John Ford

SUBJECT: Minutes of the 6th Water Quality Work Group Meeting.

The sixth meeting of the Water Quality Work Group was held between 10:00 a.m. and 1:00 p.m. Monday, September 19, at the Corps of Engineers Conference Room, Rock Island, Illinois. Those in attendance were:

Bob Kolb	USEPA, Region VII
Rich Breitenbach	USEPA
George Johnson	RICOE
Bryan Goodrum	RICOF
Wayne Harnel	RICOF
Chuck Gendelmann	University of Iowa
Rick Bell	University of Iowa
Jerry Schmoor	University of Iowa
John Ford	Missouri DNR

Dr. Schmoor gave a one hour presentation on his two contracts with the EPA. He summarized preliminary findings of his work.

Modeling of Suspended Sediment Plumes. Return flows at the Rock Island and Leithsburg sampling sites showed increases in suspended sediments of up to 75 mg/l over ambient levels in the river. There was no discernible return flow at Hannibal. Sand-sized material settled within the first 100 meters and silt sized particles, some as small as 400 to 500 microns.

The Weshler-Carter model and the Koch-Herskovler model were evaluated for use in determining the rate of use. The Weshler-Carter model, originally developed for estuaries, was found to work on conditions more typical of the Upper Mississippi. The model has been modified in the solution and was not recommended for long duration releases and the Koch-Herskovler model has no premise and can utilize "point" as well as "distributed" suspended material. A "line" source is a more accurate description of the river and beach nourishment disposal than a "point" source. A third model is being developed by Sagre. The final report will contain 27 solutions for the Weshler-Carter model, representing a variety of conditions, and a user manual.

Lab. Description of Pollutants: Three sediment samples each from 10 sites were analyzed as was river water and elutriates. At some sites there was considerable variation in the size and character of the pollutants. As expected sandy sediment were generally very low in pollutants and finer sized sediments somewhat higher. In general, ammonia, COD, Manganese and sometimes oil and grease, Cadmium and Zinc were desorbed from sediments. Iron, Phosphate, and Copper seem to adsorb to sediments during elutriate tests.

Memo-Water Quality Work Group

Page 2

September 19, 1979

Water quality standards violations in elutriates occurred infrequently. The secondary drinking water standard for Manganese was occasionally exceeded.

There was a short discussion of various agencies interpretation of what constitutes adequate documentation of water quality impacts as required in section 404 of the Federal Clean Water Law. Bob Koke said EPA had not made a decision on that question yet. John Ford of Missouri DNR said that Missouri has not addressed the problem either.

Recommendations 1-10 were accepted and will be presented at the Plan Formulation Work Group's meeting in October.

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MEMORANDUM

V. Ramaiah	MEMBER
Bill Nicholas	Iowa DEQ
Doug Morris	U.S. Fish & Wildlife Service
Steven Baumgard	Iowa DEQ
Jerry Schnoor	University of Iowa
Wayne Hannel	Corps of Engineers
Bill Whetstone	" "
Ruth Andrews	" "
George E. Johnson	" "
Bryan J. Goodrum	" "

1. Terry Teppen, Chairman of the WQSG of GREAT I, informed me that two locks at dams in the Upper Illinois River were shut down for maintenance and suggested that GREAT II sample these pools for tow traffic related water quality problems. The subsequent discussions with the Chicago District COT and Dr. E. R. Smith of Illinois Natural History Survey revealed two sources of data: the COT's routine monitoring program and INHS's sampling with SDC's funding from the U.S. Fish & Wildlife Services. I was informed by Illinois EPA and the COT that their resources are limited and cannot extend any assistance in the study; the Chicago District COT also indicated that they could neither their personnel nor to include GREAT's specific area of concern. However, as it stands, we will have limited data made available to us by the COT. These data will include turbidity, total solid, suspended solids, DO, hardness, alkalinity and pH.
2. George Johnson and Bill McIntire made a presentation on this reach dredging disposal program. As it stands, there will be three disposal sites: near Hannibal, MO, near Davenport, IA at 481.6, below Hannibal at 490.7, and below Davenport at 500.0. The disposal site at all sites except near Davenport will be shallow, in fact the return flow is expected to carry very little dredge material back to the river. But at the site near Davenport, the disposal site is located very near the bank and expected to create the worst turbidity problem in the return flow. The DOD has the following sites:

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Modeling: (a) Near Davenport at 481.5;  
(b) Above Hannibal at 314.0 ;  
(c) Below Saverton at 302.0

Lab Simulation. Six main channel stations were chosen at historical dredge cut :

- (a) Below Maquoketa River at MP 547-548;
- (b) Below Clinton River at MP 503-504;
- (c) Below Davenport at Montpelier, at MP 469.5;
- (d) Below Muscatine at Bass Island at MP 448.0;
- (e) Below Keokuk at Fox Island at MP 354.0;
- (f) Below Quincy at NE Power at MP 320.0.

In addition four side channel or slough stations were also chosen.

- (a) Below Bellevue in Apple-Moier Ditch at 545.8;
- (b) Below Clinton in Steamboat Slough at 503-504;
- (c) Below Keithsburg in Burnt Pocket at 422.0;
- (d) Below Keokuk in Grays' Chute at 355.0.

3. On Site Inspection Team.

Steven Baumgart, Iowa DEQ, has been a member of the OSIT for all sites above the confluence of Des Moines and Mississippi River. It was agreed that the Chairman of the WQWG will represent the WQWG on the OSIT for all sites below Des Moines River. Thus the concerns of the WQWG will be adequately represented at all on-site inspections.

4. The interested persons are invited to observe the dredging and disposal during this year's operation. The potential sites are indicated under Item 2 above, although the dates are set only tentatively. The season is expected to start on September 25 and continue for two weeks. As soon as I receive any information on this subject, I will transmit them to you and strongly urge everyone to observe at least one operation.

VP/IB

C. CONTRACT REPORTS

(Published Under Separate Cover)

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105

AN  
INVENTORY OF POINT SOURCE DISCHARGES TO THE  
MISSISSIPPI RIVER, GUTTENBERG, IOWA, TO  
SAVERTON, MISSOURI

COMPILED BY THE  
GREAT II  
WATER QUALITY WORK GROUP

FOR  
THE POLK ISLAND DISTRICT, CORPS OF ENGINEERS  
CLOCKTOWER BUILDING, ROCK ISLAND, ILLINOIS

MARCH, 1980

INVENTORY OF POINT SOURCE DISCHARGES TO THE MISSISSIPPI RIVER,  
GUTTENBERG, IOWA TO SAVERTON, MISSOURI

This document contains 38 maps and one table which locate and describe point source discharges to the Great II segment of the Upper Mississippi River. The information was obtained through the 303(c) basin plans from the states involved. These documents were published in 1970. The state is responsible for development of the information and is contacted for more information in the future. All discharges are either directly into the Mississippi or to a tributary which subsequently flows into the Mississippi within approximately 2 miles of the discharge.

The table has nine columns. Column 1 is the number given to the discharge and corresponds to the number locating the discharge on the accompanying maps. Column 2 is the name of the facility and includes abbreviations for sewage treatment plants (STP), water treatment plants (WTP), and health parks (MHP). Column 3 gives the location and column 4 gives the approximate river mile of the discharge. Columns 5-8 describe, where known, the character of the wastewater discharge. This information came from the basin plans, documents and from wastewater monitoring data collected by the states. Column 5 gives the quantity of the discharge. Actual discharges are given whenever that information was available. If only the design flow (what the facility was built to accommodate) is known, it was listed in parentheses. Column 6 is an estimate of the 5-day BOD (Biological Oxygen Demand) or organic pollution load discharged. Column 7 estimates the amount of ammonia nitrogen discharged. Column 8 may indicate how the wastewater was generated and what sorts of pollutants other than organic materials it may contain. Column 9 gives the name of the stream receiving the discharge.

It should be noted that the quality and quantity of wastewater discharge, particularly those of industries, are highly variable and much of the information in Columns 5-7 are based on a relatively few samples. The information presented in these columns should therefore be considered to be a display of available data rather than an accurate estimate of the quality and quantity of the wastewater discharges.

No.	Name of Facility	Location	River Mile	Actual (Design) (MGD) Vol. of Flow	Lbs. Avg. BOD <sub>5</sub>	Lbs. NH <sub>3</sub> -N of wastewater	Character or Constituents of wastewater	Receiving Stream
14	Watterson SLP	Watterson	614		600	60		Miners Cr.
15	Watterson Power Plant	Watterson	608	165				Mississippi R.
16	Watterson SLP	"	607.5	.025	6			Furnace Cr.
17	Watterson SLP	"	607.5	.048	9			Furnace Cr.
18	Watterson SLP	"	606.8	46.5				Mississippi R.
19	Watterson SLP	"	606.5	.144	14			Mississippi R.
20	Watterson SLP	Forest	592	.251	21			Mississippi R.
21	Watterson SLP	"	585.6		55		Cr., Pb., Zn	Little Manquoketa
22	Watterson SLP	"	583.6	17.000	550		Cooling Water	Little Manquoketa
23	Watterson SLP	"	583.6	(.002)				Little Manquoketa
24	Watterson SLP	"	581	(.011)				Mississippi R.
25	Watterson SLP	"		(.715)			Cooling Water	Mississippi R.
26	Watterson SLP	"		(.648)			Cooling Water	Mississippi R.
27	Watterson SLP	"		(61.1)			Cooling Water	Mississippi R.
28	Watterson SLP	"		(.756)			Cooling Water	Mississippi R.
29	Watterson SLP	"		(.003)			Cooling Water	Mississippi R.
30	Watterson SLP	"		(2.31)			Cooling Water	Mississippi R.
31	Watterson SLP	"		.027			Discharge to Storm Sewer	Mississippi R.
32	Watterson SLP	"						Mississippi R.
33	Watterson SLP	"						Mississippi R.
34	Watterson SLP	"						Mississippi R.
35	Watterson SLP	"						Mississippi R.
36	Watterson SLP	"						Mississippi R.
37	Watterson SLP	"						Mississippi R.
38	Watterson SLP	"						Mississippi R.
39	Watterson SLP	"						Mississippi R.
40	Watterson SLP	"						Mississippi R.
41	Watterson SLP	"						Mississippi R.
42	Watterson SLP	"						Mississippi R.
43	Watterson SLP	"						Mississippi R.
44	Watterson SLP	"						Mississippi R.
45	Watterson SLP	"						Mississippi R.
46	Watterson SLP	"						Mississippi R.
47	Watterson SLP	"						Mississippi R.
48	Watterson SLP	"						Mississippi R.
49	Watterson SLP	"						Mississippi R.
50	Watterson SLP	"						Mississippi R.
51	Watterson SLP	"						Mississippi R.
52	Watterson SLP	"						Mississippi R.
53	Watterson SLP	"						Mississippi R.
54	Watterson SLP	"						Mississippi R.
55	Watterson SLP	"						Mississippi R.
56	Watterson SLP	"						Mississippi R.
57	Watterson SLP	"						Mississippi R.
58	Watterson SLP	"						Mississippi R.
59	Watterson SLP	"						Mississippi R.
60	Watterson SLP	"						Mississippi R.
61	Watterson SLP	"						Mississippi R.
62	Watterson SLP	"						Mississippi R.
63	Watterson SLP	"						Mississippi R.
64	Watterson SLP	"						Mississippi R.
65	Watterson SLP	"						Mississippi R.
66	Watterson SLP	"						Mississippi R.
67	Watterson SLP	"						Mississippi R.
68	Watterson SLP	"						Mississippi R.
69	Watterson SLP	"						Mississippi R.
70	Watterson SLP	"						Mississippi R.
71	Watterson SLP	"						Mississippi R.
72	Watterson SLP	"						Mississippi R.
73	Watterson SLP	"						Mississippi R.
74	Watterson SLP	"						Mississippi R.
75	Watterson SLP	"						Mississippi R.
76	Watterson SLP	"						Mississippi R.
77	Watterson SLP	"						Mississippi R.
78	Watterson SLP	"						Mississippi R.
79	Watterson SLP	"						Mississippi R.
80	Watterson SLP	"						Mississippi R.
81	Watterson SLP	"						Mississippi R.
82	Watterson SLP	"						Mississippi R.
83	Watterson SLP	"						Mississippi R.
84	Watterson SLP	"						Mississippi R.
85	Watterson SLP	"						Mississippi R.
86	Watterson SLP	"						Mississippi R.
87	Watterson SLP	"						Mississippi R.
88	Watterson SLP	"						Mississippi R.
89	Watterson SLP	"						Mississippi R.
90	Watterson SLP	"						Mississippi R.
91	Watterson SLP	"						Mississippi R.
92	Watterson SLP	"						Mississippi R.
93	Watterson SLP	"						Mississippi R.
94	Watterson SLP	"						Mississippi R.
95	Watterson SLP	"						Mississippi R.
96	Watterson SLP	"						Mississippi R.
97	Watterson SLP	"						Mississippi R.
98	Watterson SLP	"						Mississippi R.
99	Watterson SLP	"						Mississippi R.
100	Watterson SLP	"						Mississippi R.



No.	Name of Facility	Location	River Mile	Actual (Design) (MGD)		Lbs. Avg. BOD <sub>5</sub>	Lbs. NH <sub>3</sub> -N	Character of Constituents of wastewater	Receiving Stream
				Vol. of Flow					
27.	Winkeshu Motor Co.	Sec. 3-7, 81N, 6E		.015				Cooling Water	Beaver Channel
28.	Continental Oil Co.	Clinton, La.	513	1.009		200		Cooling Water Cr. Org. N. NO <sub>3</sub> -N	Beaver Channel
29.	Lawrence Chemical Co.	Lat. 1-36-10 Long. 90-16-50		2.100 (93)	259	21		Zn. Cr. Cooling Water, Settling Pond (Ash) Discharge	Mississippi R. Mill Cr.
30.	Comptex, Inc.	Clinton, La.			-	-		Cooling Water	Mississippi R.
31.	Interstate Power Co.	Clinton, La.						Pond (Ash) Discharge	Mill Cr.
32.	International Paper Co.	Clinton, La.						Cooling Water	Mill Cr.
33.	Clarks Co.	Clinton, La.		.150	226	5		Plating Wastes, Metals	Mill Cr.
34.	Clinton S. R.R.	Clinton, La.		(.020)				Sanitary Wastes	Mill Cr.
35.	Beaver Channel Parkway	Beaver Channel Parkway	514	7.00	18,020	900		Includes Wastewater from Union Carbide. Cr., Zn, Cd, Ni	Beaver Channel of Mississippi R.
36.	Aluminum Pipe	Sec. 8, 81N, 6E 81N, 2E	514	.070	90	20			Mississippi R.
37.	Campanche RPT Pump and SPP	Campanche, La. Sec. 23, 81N, 6E (Swan Slough)	514	.70	800	80		Wastewater from Central Steel Corp. Included. Metals.	Swan Slough Swan Slough of Mississippi R.
38.	Large Mill Co.	NT, Sec. 3, 29N, 1E	508	5.3	1,446	1,271		Iron, Oxide	Mississippi R.
39.	Chemical Co.	Sec. 8, 81N, 6E 81N, 2E	514	-	-	-		Cooling Water	Mississippi R.
40.	Chemical Co.	Sec. 23, 81N, 6E 81N, 2E	508	.040	5	1		Process Domestic Waste	Mississippi R.
41.	Chemical Co.	Sec. 23, 81N, 6E 81N, 2E	508	.040	1	1			Mississippi R.
42.	Chemical Co.	Sec. 23, 81N, 6E 81N, 2E	508	.050	9	1			Mississippi R.
43.	Chemical Co.	Sec. 23, 81N, 6E 81N, 2E	508	.12	20	6			Pitt to Miss. R.
44.	Chemical Co.	Sec. 23, 81N, 6E 81N, 2E	508						Mississippi R.

[illegible]



No.	Name of Facility	Location	River Mile	Vol. of Flow (MGD)	Lib. Avg. 800 <sub>5</sub>	Lib. NH <sub>3</sub> -N of wastewater	Character or Constituents	Receiving Stream
1	Industrial effluent Pine Bluff, Ark.			1.000				Mississippi R.
2	Wastewater treatment plant Pine Bluff, Ark.			1.000				Mississippi R.
3	Wastewater treatment plant Pine Bluff, Ark.			1.000				Mississippi R.
4	Wastewater treatment plant Pine Bluff, Ark.			1.000				Mississippi R.
5	Wastewater treatment plant Pine Bluff, Ark.			1.000				Mississippi R.
6	Wastewater treatment plant Pine Bluff, Ark.			1.000				Mississippi R.
7	Wastewater treatment plant Pine Bluff, Ark.			1.000				Mississippi R.
8	Wastewater treatment plant Pine Bluff, Ark.			1.000				Mississippi R.
9	Wastewater treatment plant Pine Bluff, Ark.			1.000				Mississippi R.
10	Wastewater treatment plant Pine Bluff, Ark.			1.000				Mississippi R.



Actual  
(Design)  
(MGD)

No. Name of Facility Location River Mile Vol. of Flow Lbs. Avg. BOD<sub>5</sub> Lbs. NH<sub>3</sub>-N of wastewater Character or Constituents of wastewater Receiving Stream

126.	Burlington STP		402.0	5,000	4,000	400	Cu, Zn, Cd, Pb, Ni, Cr	Mississippi R.
127.	American Oil Co.		402.5	(.022)				Mississippi R.
128.	Iowa So. Utilities	Burlington, Ia.		(.115)			Cooling water permeate Limits for pH, 0.90, BOD <sub>5</sub> S.S. Residual Cl, 100	Mississippi R.
129.	West Burlington STP		398.3	.451	300	38	Metals	Spring Cr.
130.	Spring Lake Pumpground		398.1					Spring Cr.
131.	Loman Coin Wash	SW, Sec. 18, 8N, 5W	395	(.005)			Sanitary & Washing Machine Wastewater	Dugout Cr.
132.	Dallas City STP	NE 1/4 Sec. 3, 7N, 7W	390	.070	10,000	10		Mississippi R.
133.	Waver Miss. Ind.			(6,200)			Cooling tower & boiler blowdown, Domestic sewage Includes Cyanide, Chlorides, Nickel & Zinc	Mississippi R.
134.	Craft MHP	NE 1/4 Sec. 17, 5N, 7W	387	.002				Trib. to Miss. R.
135.	The Madison Co.		381				Lime, Sludges, Filter cake, wash	Upper Per. Cr.
136.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W	381	.685	12,500		Process & Cooling Water	Mississippi R.
137.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W		2,000			Cr.	Mississippi R.
138.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W	381.7	5,000	6,000	600	Em. By Union Carbide Stormwater Runoff Fueling area Cooling water & blowdown Permit limited Cooling water	Mississippi R.
139.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
140.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
141.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
142.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
143.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
144.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
145.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
146.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
147.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
148.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
149.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
150.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
151.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
152.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
153.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
154.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
155.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
156.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
157.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
158.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
159.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
160.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
161.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
162.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
163.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
164.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
165.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
166.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
167.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
168.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
169.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
170.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
171.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
172.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
173.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
174.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
175.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
176.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
177.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
178.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
179.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
180.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
181.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
182.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
183.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
184.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
185.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
186.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
187.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
188.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
189.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
190.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
191.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
192.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
193.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
194.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
195.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
196.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
197.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
198.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
199.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.
200.	Union Carbide	SE 1/4 Sec. 17, 7N, 5W						Mississippi R.

No.	Name of Facility	Location	River Mile	Actual (Design) (MGD)		Vol. of Flow	Lbs. Avg. BOD <sub>5</sub>	Lbs. NH <sub>3</sub> -N	Character or Constituents of Wastewater	Receiving Stream
164.	Pl. Madison, La. West STP	Sec. 12, 67N, 7W	380	.028	70	6				Mississippi R.
165.	Armour-Pill (La.)	Lat. 40-34-12 Long. 94-23-57	379	2.000	700	313			Process Water Domestic Wastewater, Cooling Water, Permit Limits for NH <sub>3</sub> -N, S.S.	Mississippi R.
166.	Chevron Chemical Co. Fryhuf Co.		379	2.000 (.012)		250			Process & Cooling Water Domestic Wastewater Metals	Mississippi R. Mississippi R. Mississippi R.
167.	American Metal Climax Co.		376		100					Mississippi R.
168.	Scientific View Mill Montrose, La., STP	Sec. 11, 66N, 5W	375	.060						Mississippi R.
169.	Various STP	SW, Sec. 1, 65N, 9W	372	.100	250	12				Mississippi R.
170.	Camp Eastman STP	Sec. 31, 65, 86	369	.005					Kitchen Waste & Swimming Pool Discharge	Trib. to Miss. R.
171.	Anderson Mill		367							Mississippi R.
172.	Phillips Mill		366.5	.018	4	1				Price Cr.
173.	Skyview Mill		366.5							Price Cr.
174.	Kodak-Hamlinhurst STP	Sec. 11, 65N, 5W	366.5	1.500	1,900	170				Mississippi R.
175.	Claude Greer Mill Hamilton Park Dist.	SW, Sec. 20, 5N, 5W	365	(.003)					Swimming Pool Backwash	Mississippi R. Trib. to Miss. R.
176.	Valley Electric Co. Hamilton, Ill. STP	Keokuk, Ia. Sec. 30, 45, 50	364.5 364.5	1.877 .450	150	40			Equipment Drainage Water	Mississippi R. Hamilton Slough
177.	Keokuk, Ia., WTP	Keokuk, Ia.	363	3.2	30,000	500				Mississippi R.
178.	Keokuk, Ia., STP	Sec. 36, 65N, 3W	363	.058					Cooling Water	Soap Cr.
179.	Minwest Garbage Co. Keokuk, Ia.	Keokuk, Ia.	363	.030					Cooling Water	Soap Cr.

No.	Name of Facility	Location	River Mile	Actual (Design) (MGD) Vol. of Flow	Lbs. Avg. BOD <sub>5</sub>	Lbs. NH <sub>3</sub> -N	Character or Constituents of wastewater	Receiving Stream
186.	Hubinger Co.	Keokuk, Ia.	363	8.700	17,500	1.282	Process & Cooling Water Permit Limits for pH, S.S. BOD, Temp.	Soap Cr.
187.	Keokuk Steel Casting	Lat. 40-23-06, Long. 91-24-31 Keokuk, Ia.	362	0.264			Cooling & Stormwater Runoff	Mississippi R.
187.	Footo Mineral Co.	Keokuk, Ia.	361.5	0.5			Stormwater Runoff, Slag Settling	
188.	Parsaw, ILL., STP	NW 1/4, Sec. 20, 4N, 9W	357	(.290)	10			Shuhart Cr.
189.	ESB Inst.-Auto Div.	NE 1/4, Sec. 20, 4N, 9W	357.5	.150	4	2	Permit Limits for F, Ph	Trib. to Miss. R.
190.	Canton, MO., STP	NW 1/4, SW 1/4, Sec. 36, 62N, 6W	342.5				Sludge Blowdown, Filter Backwash	Mississippi R.
191.	Canton, MO., STP	SW 1/4, SW 1/4, Sec. 36, 62N, 6W	342	(.419)	104			Mississippi R.
191.	River Valley Country Club	SW 1/4, SE 1/4, Sec. 13, 61N, 6W	339	(.001)				Drainage Ditch to Mississippi R.
191.	Triangle Refineries	Lafayette, MO.	337				Stormwater Runoff from gas loading Facility	Mississippi R.
194.	Lafayette, MO., STP	Main at Knox St.	335.5	(.300)	75			Mississippi R.
195.	Firestone Inc.	Quincy, IL.	328				Cooling Water	Redmond Branch of Cedar Creek
196.	Moorman Mfg.	Quincy, IL.	328				Cooling Water	Redmond Branch of Cedar Creek
197.	Celotex Inc.	Quincy, IL.	326.5	2.06	166		Permit Limits for P, Phenol, Ozone, H <sub>2</sub> O <sub>2</sub> , BOD, TSS, Kmn, Process water, cooling water.	Mississippi R.
198.	Quincy, ILL., STP	SW 1/4, Sec. 11, 2S, 1E	340	6.06	1,000			Mississippi R.
199.	Quincy Sashboard Co.	SW 1/4, Sec. 14, 1E, 2S	327	5.00			Cooling Water	S. Quincy Drainage Ditch

Actual  
(Design)  
(MCD)

Lbs.  
Avg.  
BOD

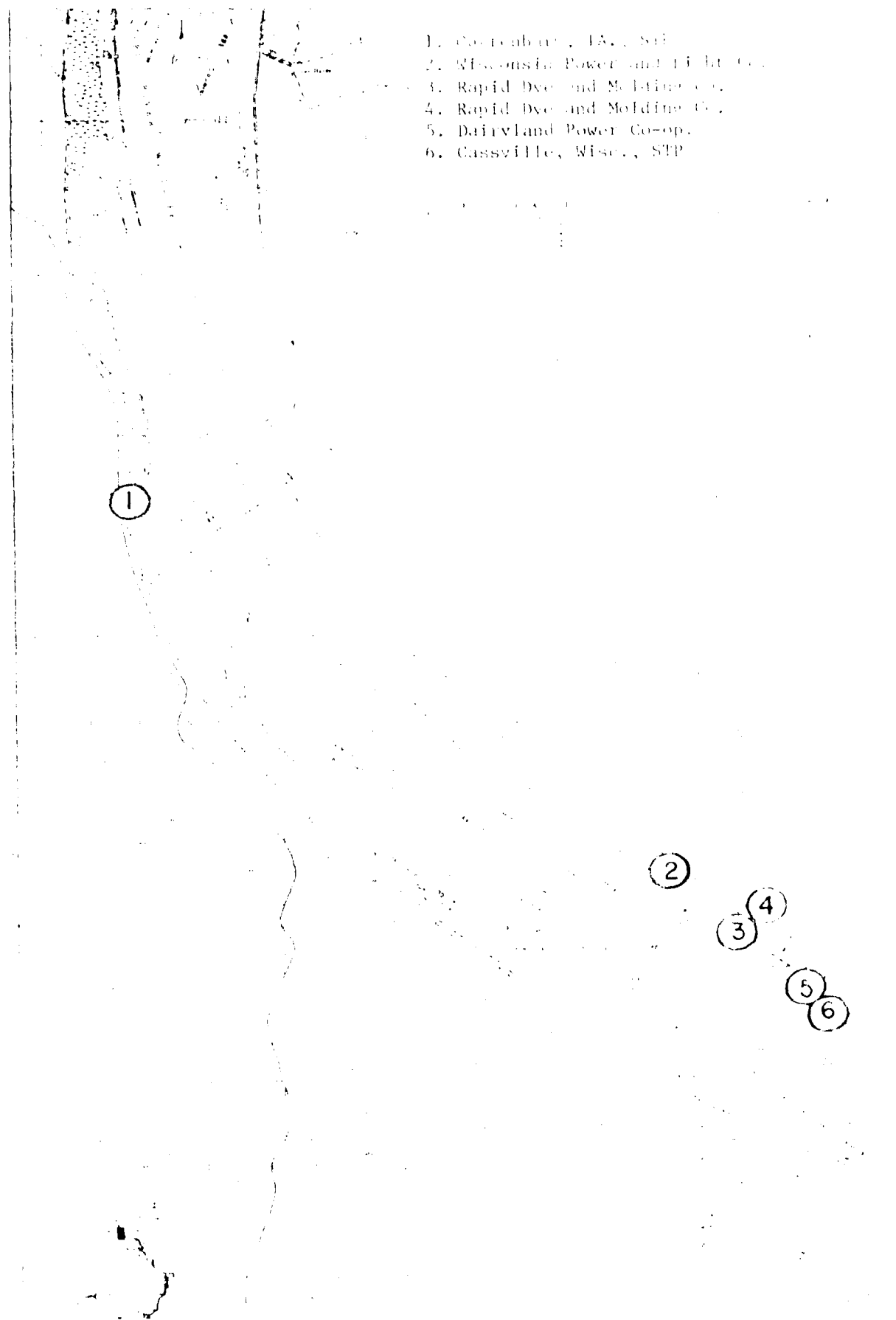
Lbs.  
NH<sub>3</sub>-N

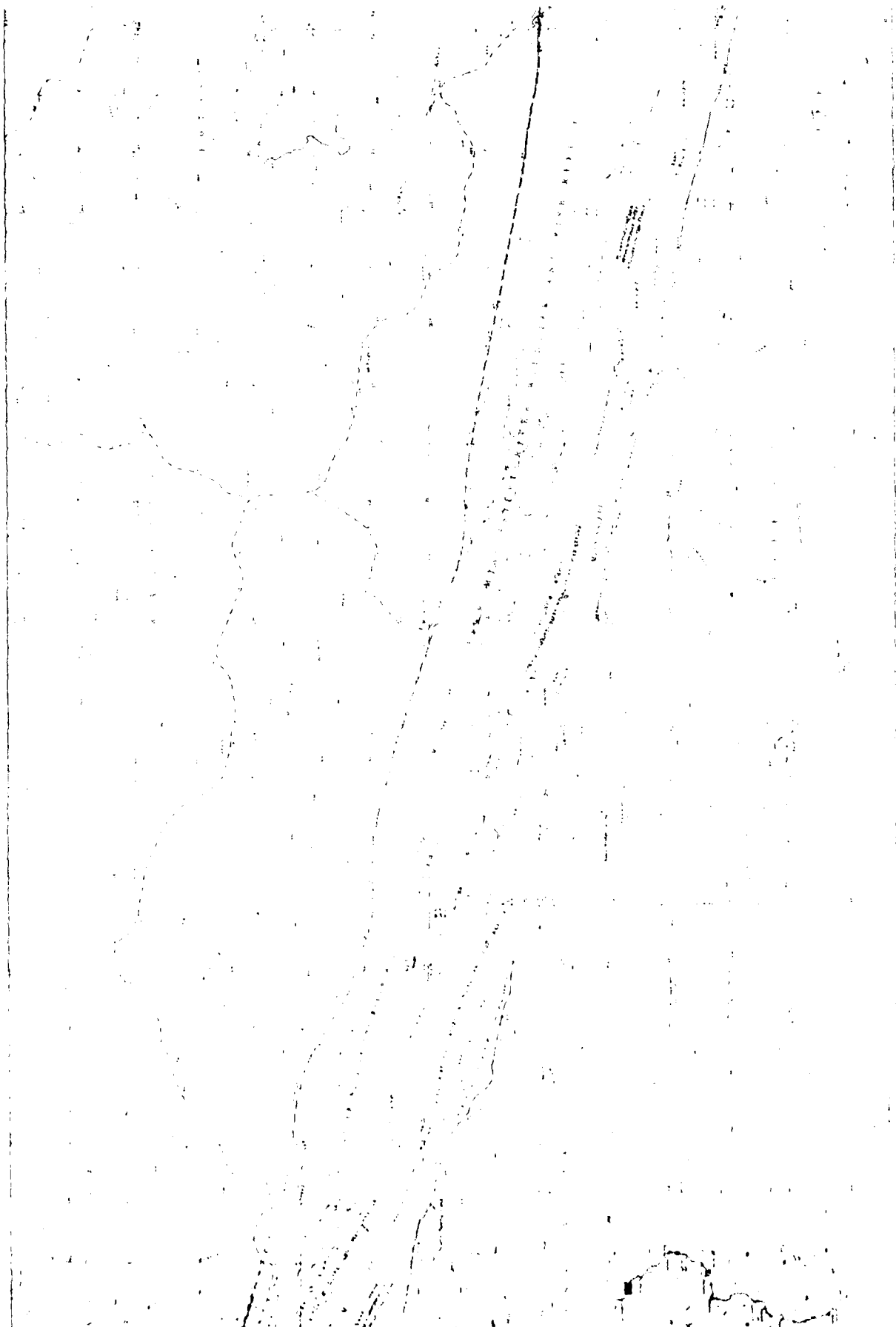
Character or Constituents  
of wastewater

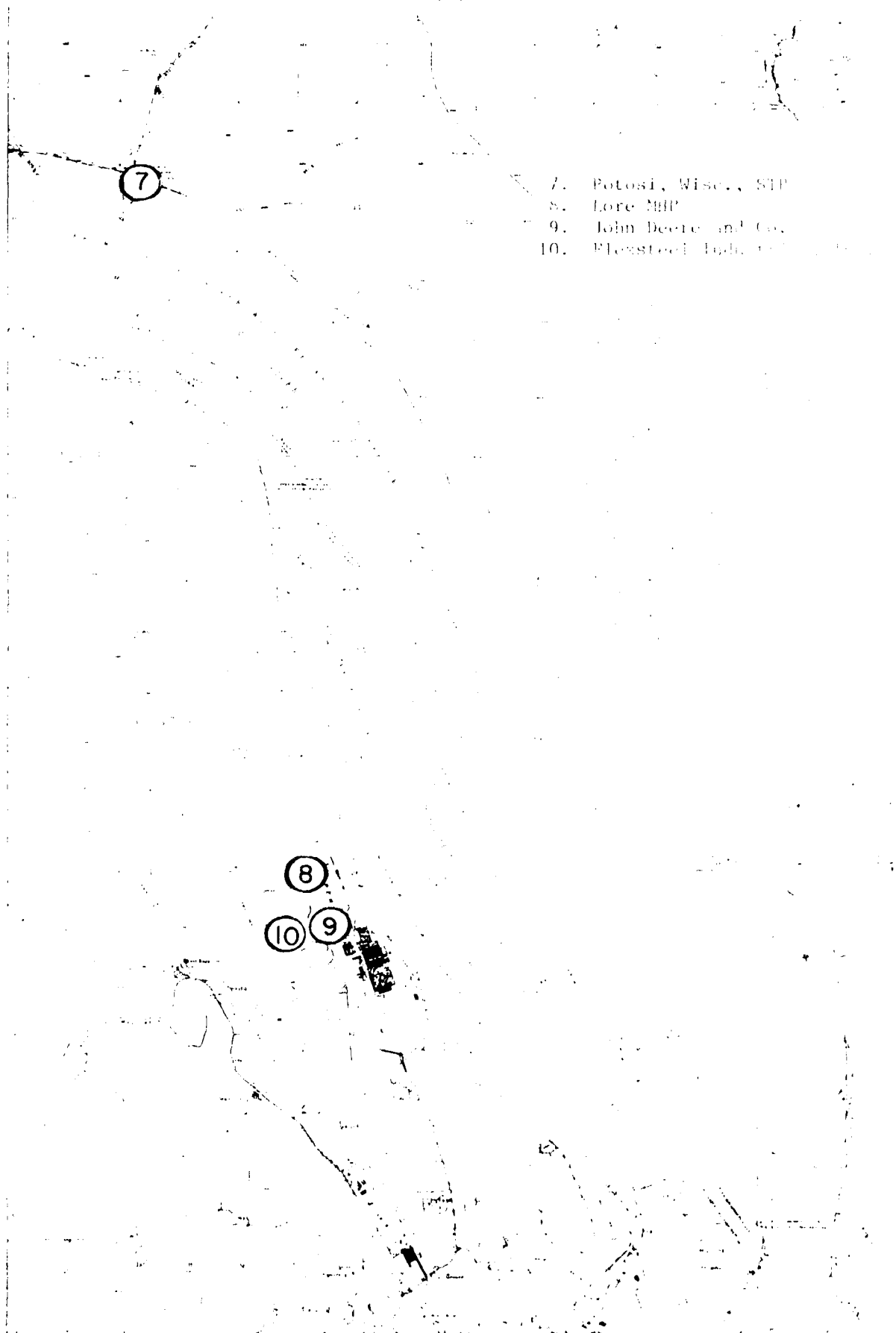
Receiving  
Stream

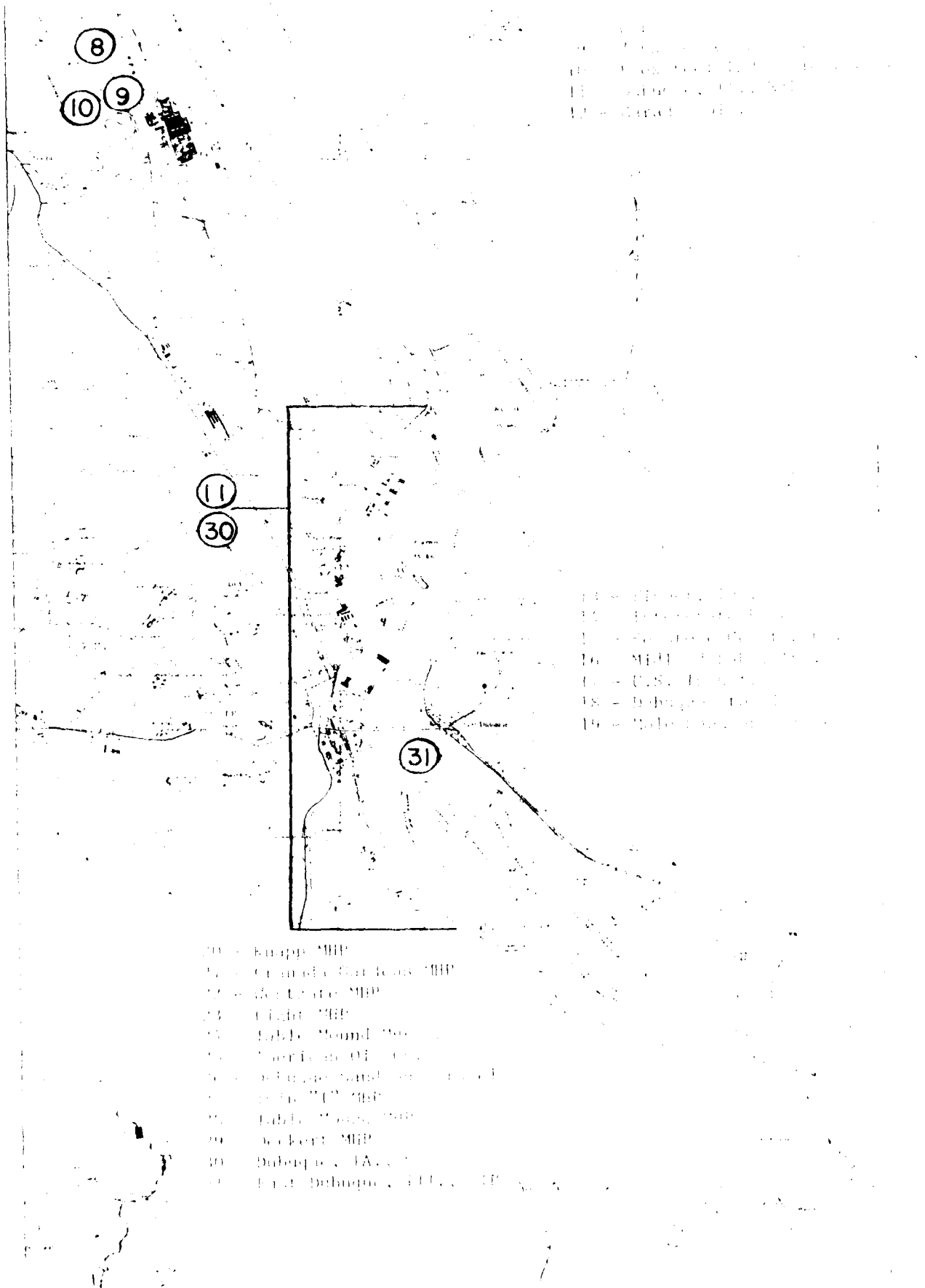
No.	Name of Facility	Location	River Mile	Vol. of Flow	Lbs. Avg. BOD	Lbs. NH <sub>3</sub> -N	Character or Constituents of wastewater	Receiving Stream
100.	Prince Mtn.	SW 1/4 Sec. 14, T. 28N, R. 32E					Cooling Water	S. Quincy Drainage Ditch
101.	MCA Plant	SE 1/4 Sec. 8, T. 28N, R. 32E	310.6	(.003)			Domestic Wastewater	Drainage Ditch
102.	C. F. Industries	SE 1/4 Sec. 3, T. 28N, R. 32E	310.6				Cooling Water	Mississippi R.
103.	American Cyanamid Co.	SE 1/4 Sec. 11, T. 28N, R. 32E	319.7				Cooling Water, Wastewater from Ammonium Nitrates & Phosphates Production	Mississippi R.
104.	M.E. Missouri Elec. Co.	SW 1/4 Sec. 10, T. 28N, R. 32E	311.7				Stormwater Runoff, Cooling Water	Mississippi R.
105.	Hunnibal, MO. W.P.	SE 1/4 Sec. 20, T. 28N, R. 32E	310				Filter Backwash & Rinsing Washwater	Mississippi R.
106.	Hunnibal, MO. W.P.	SE 1/4 Sec. 20, T. 28N, R. 32E	310.1					Mississippi R.
107.	Burlington- Northwestern P.R.	NE 1/4 Sec. 20, T. 28N, R. 32E	310.1				Stormwater Runoff & Domes- tic Wastes from Railroad Yard	Spooner Cr.- Mississippi R.

1. Coonbush, W.A., Sd
2. Wisconsin Power and Light Co.
3. Rapid Dye and Molding Co.
4. Rapid Dye and Molding Co.
5. Dairyland Power Co-op.
6. Cassville, Wisc., STP



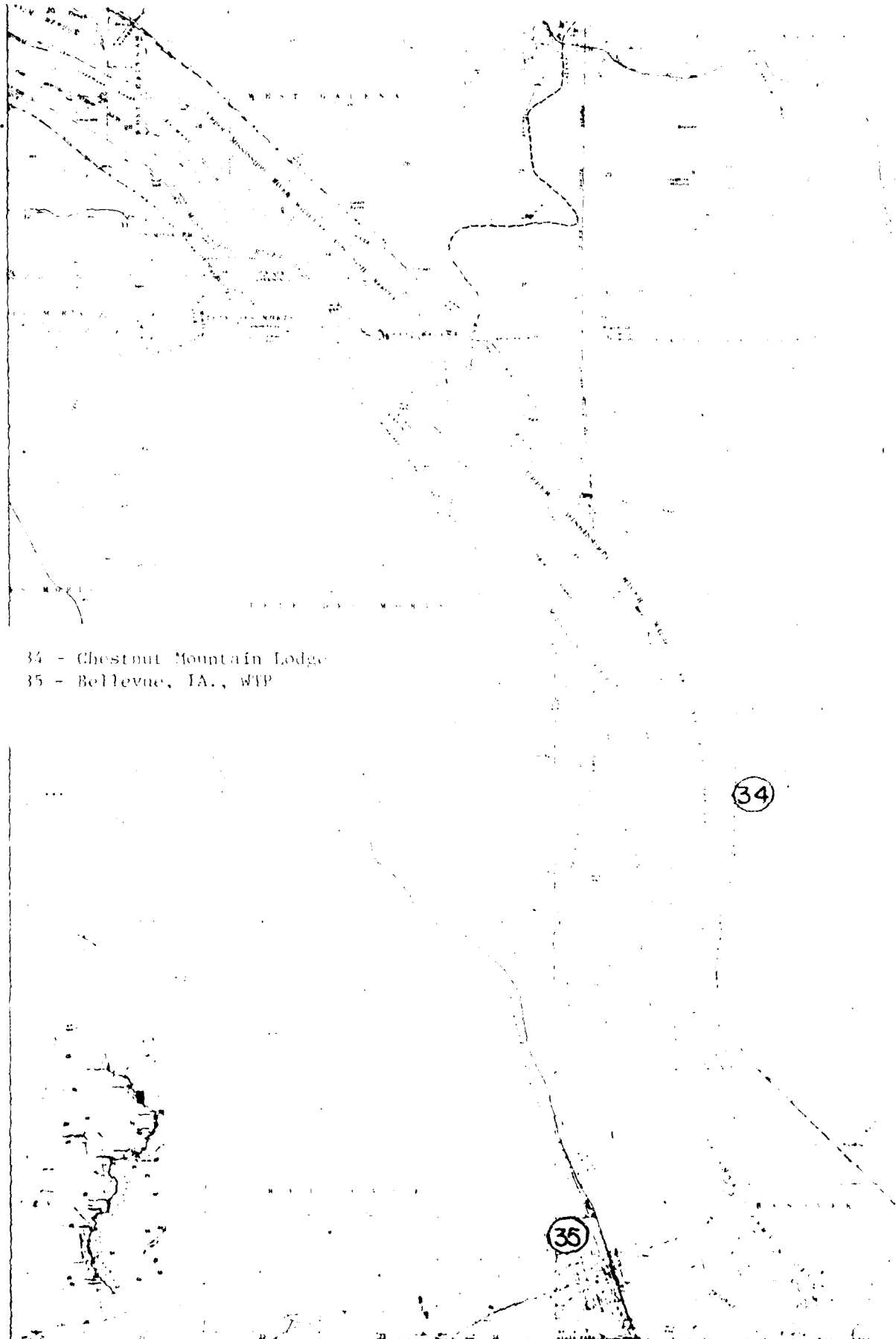




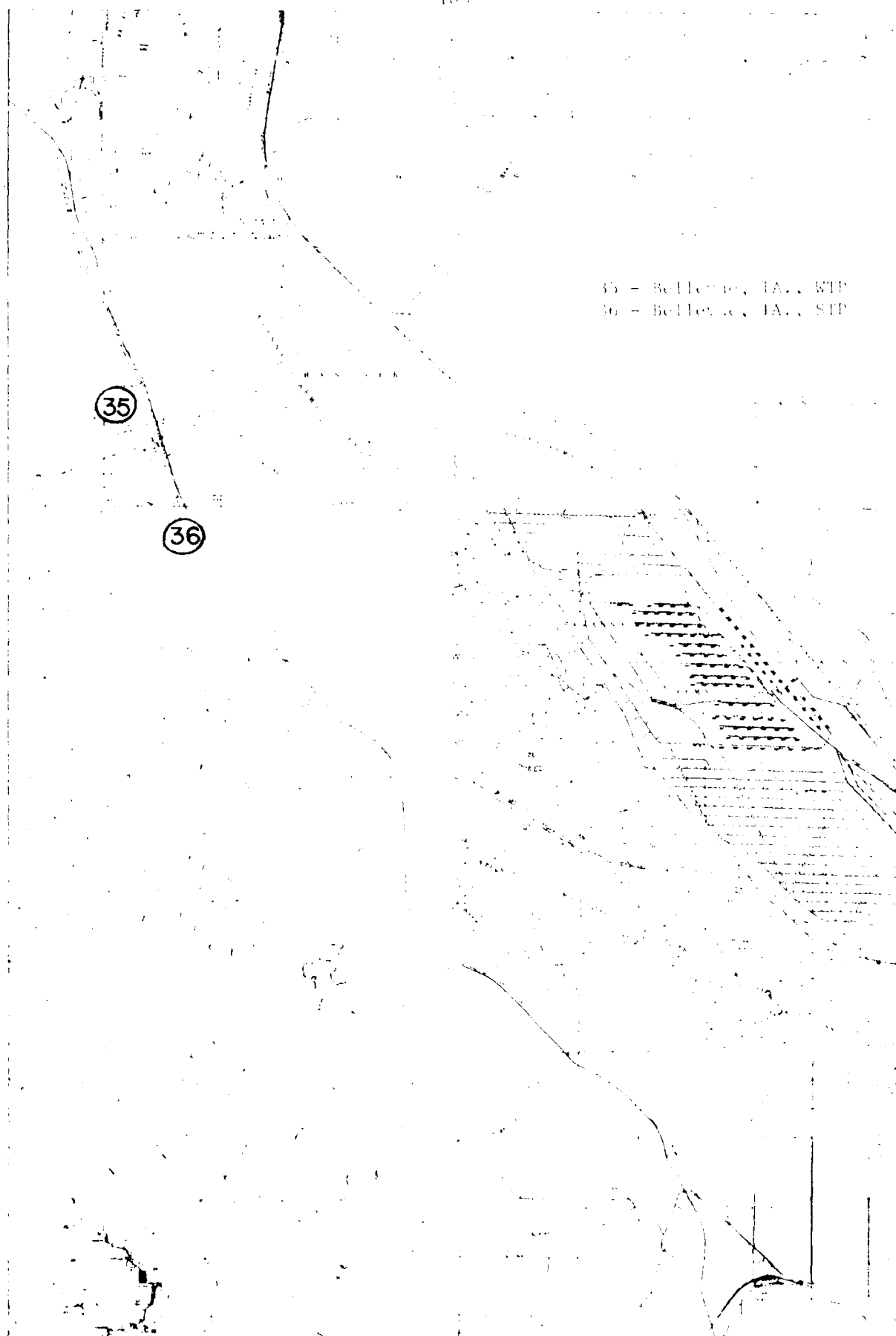


11 - Andover Chemical Co.  
13 - Andover Chemical Co.

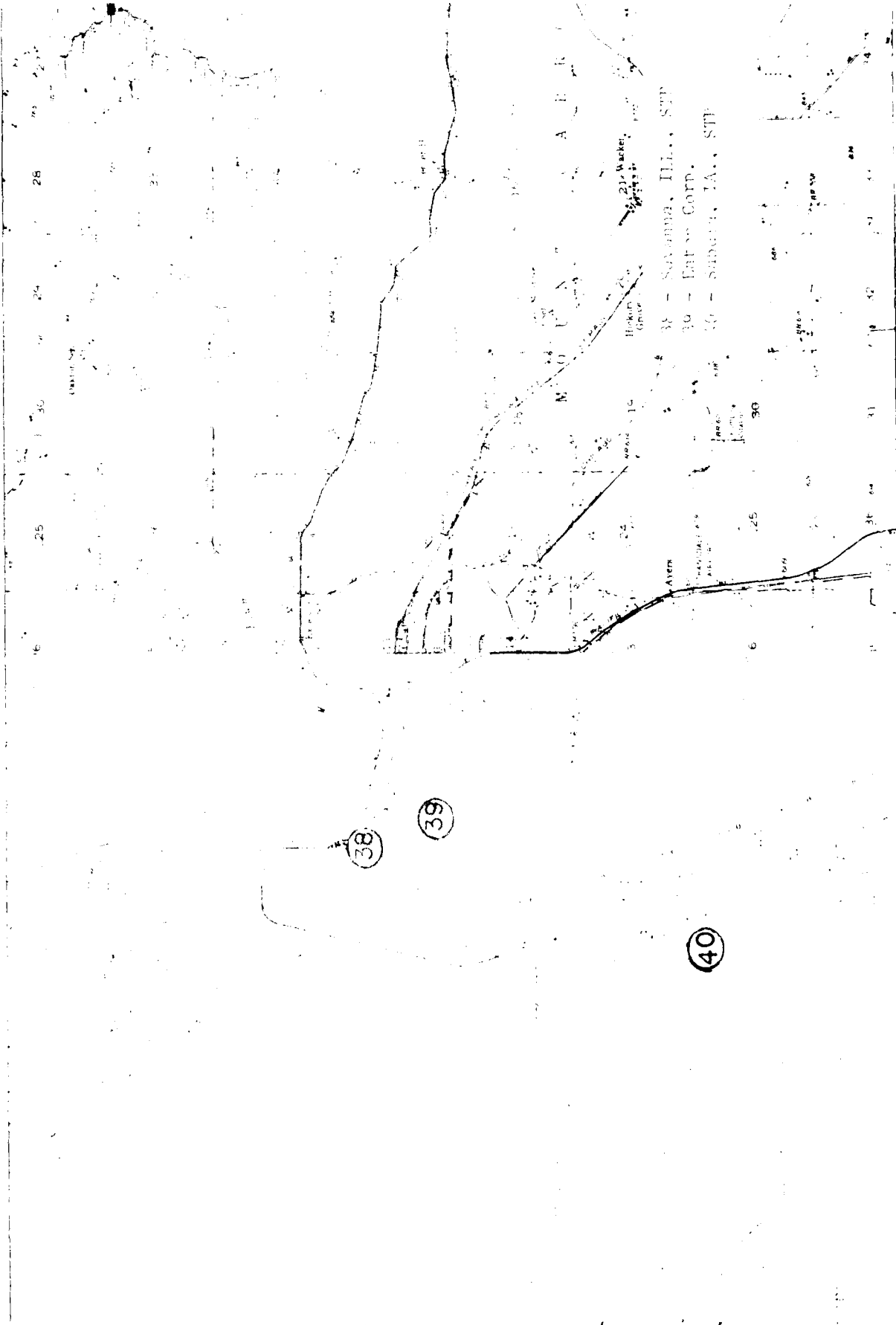




34 - Chestnut Mountain Lodge  
35 - Bellevue, IA., WTP







UNCLASSIFIED

IOWA INST OF HYDRAULIC RESEARCH IOWA CITY F/G 8/8  
GREAT II UPPER MISSISSIPPI RIVER (GUTTENBERG, IOWA TO SAVERTON--ETC(U)  
DEC 80 DACW25-78-C-0048

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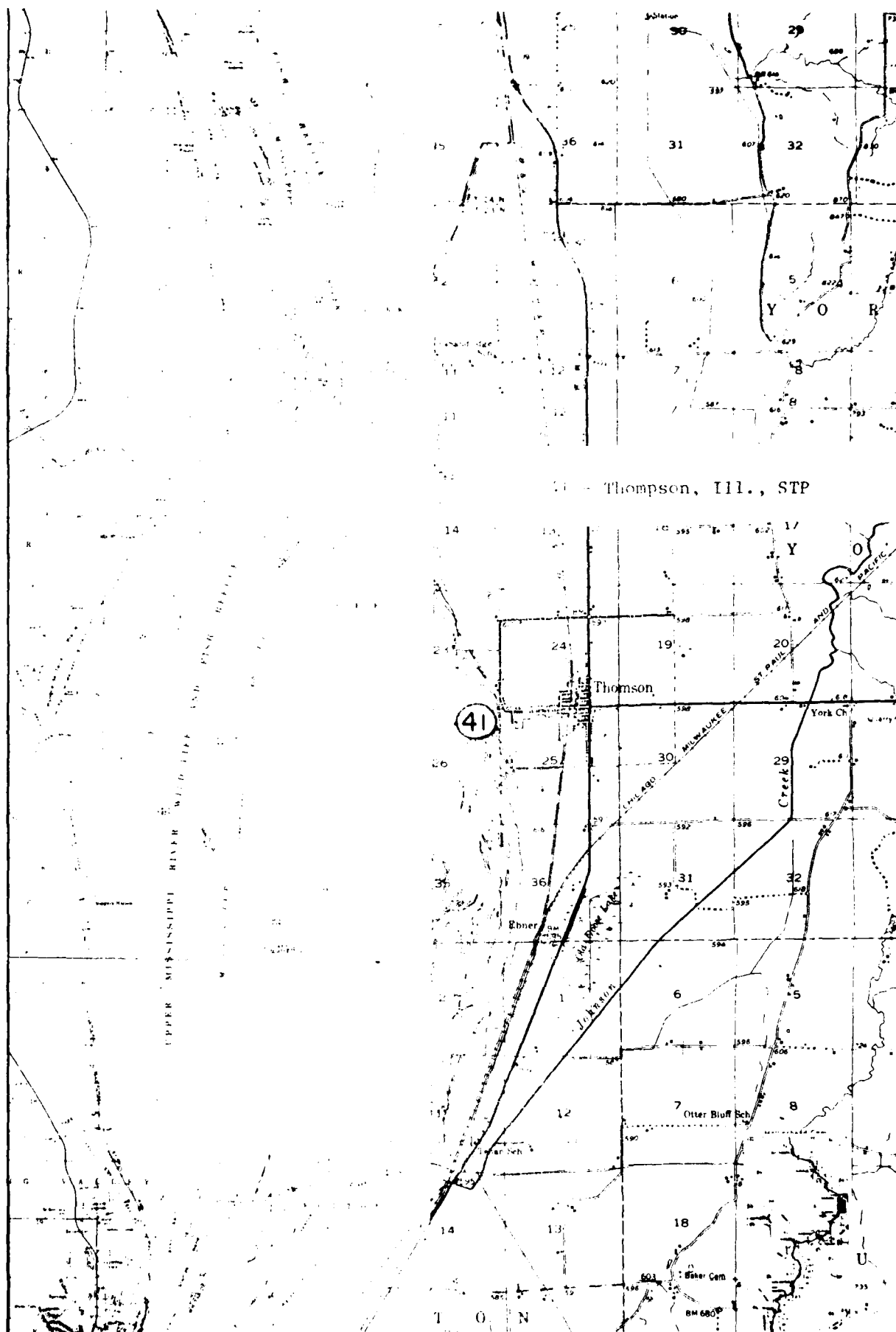
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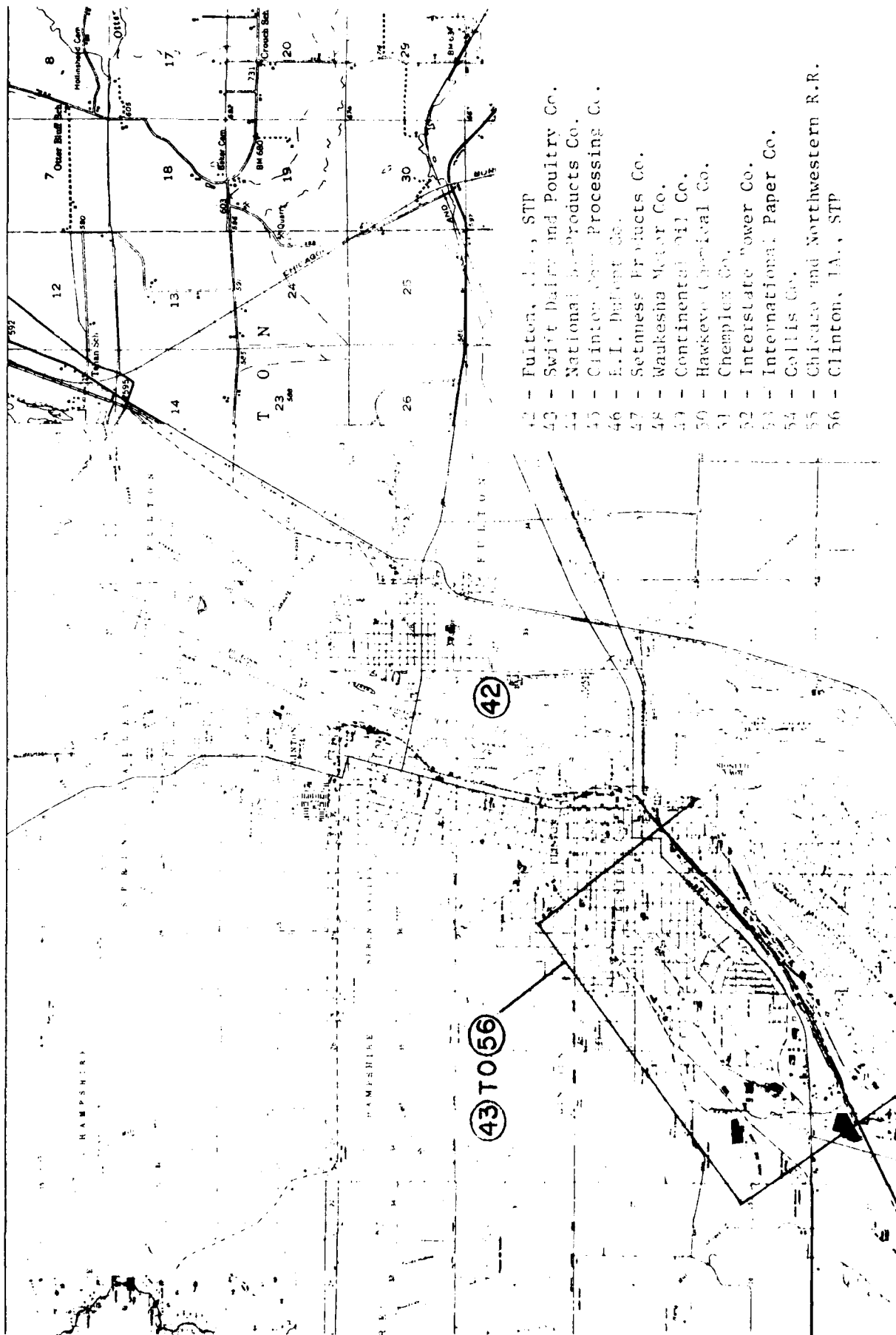
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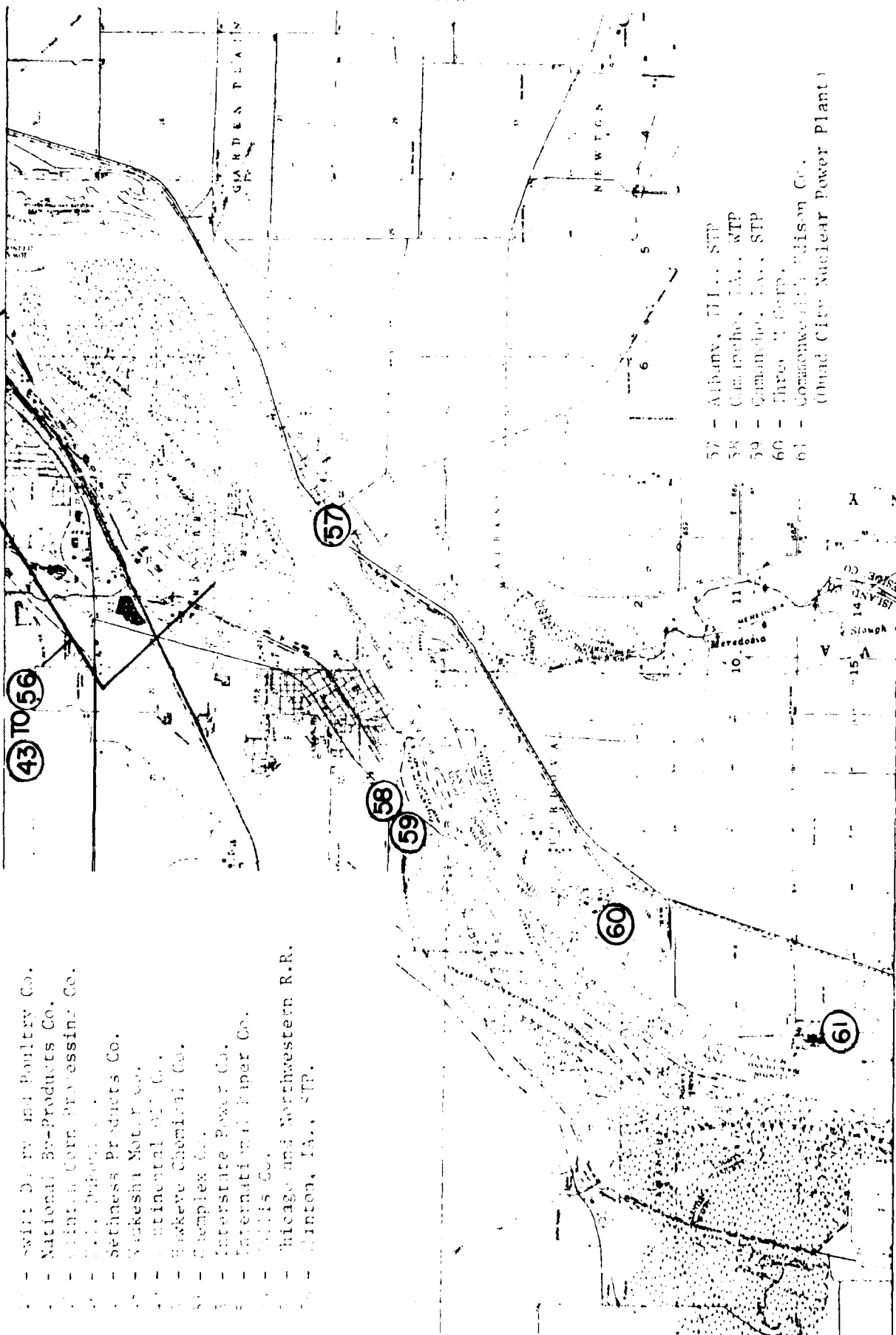
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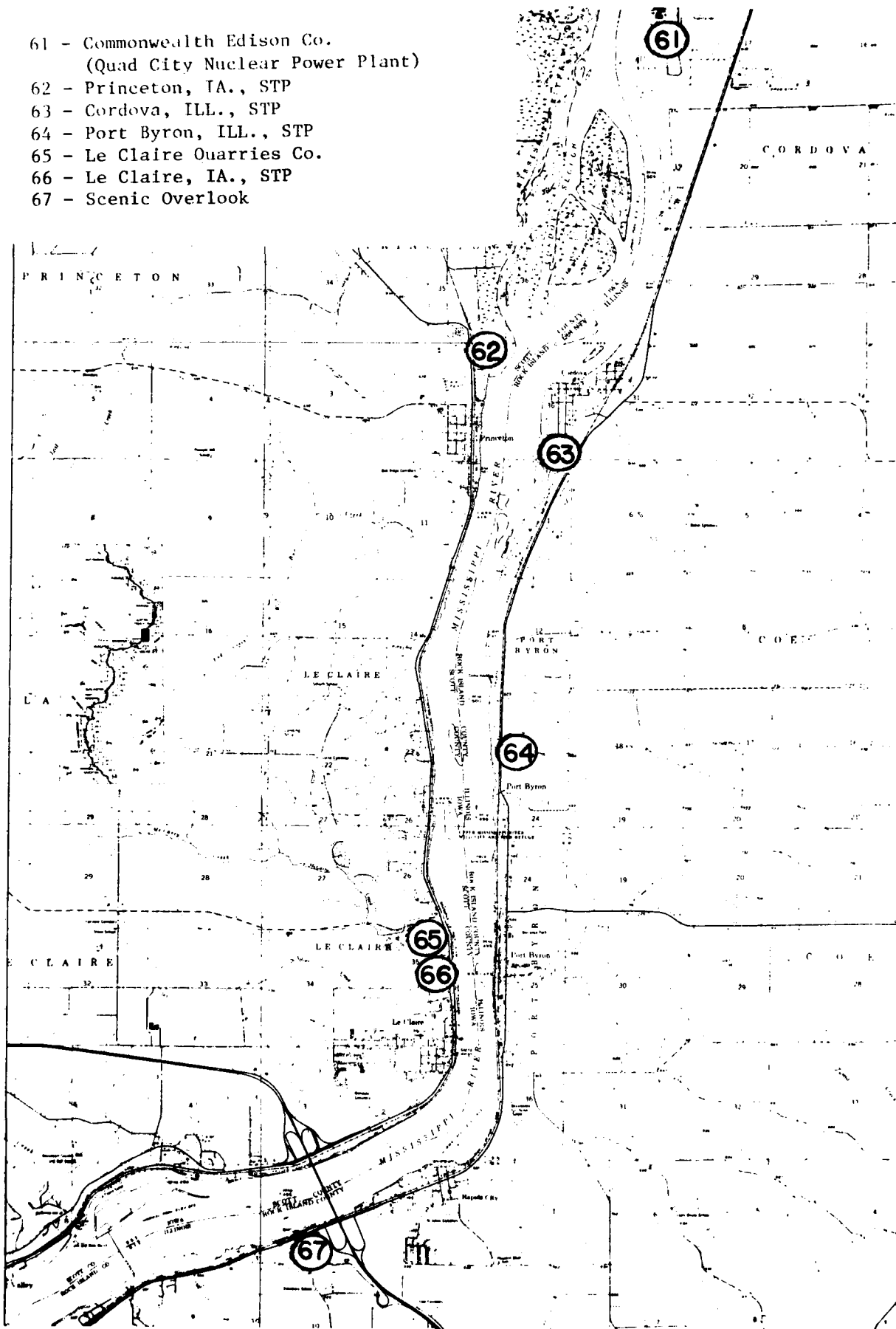




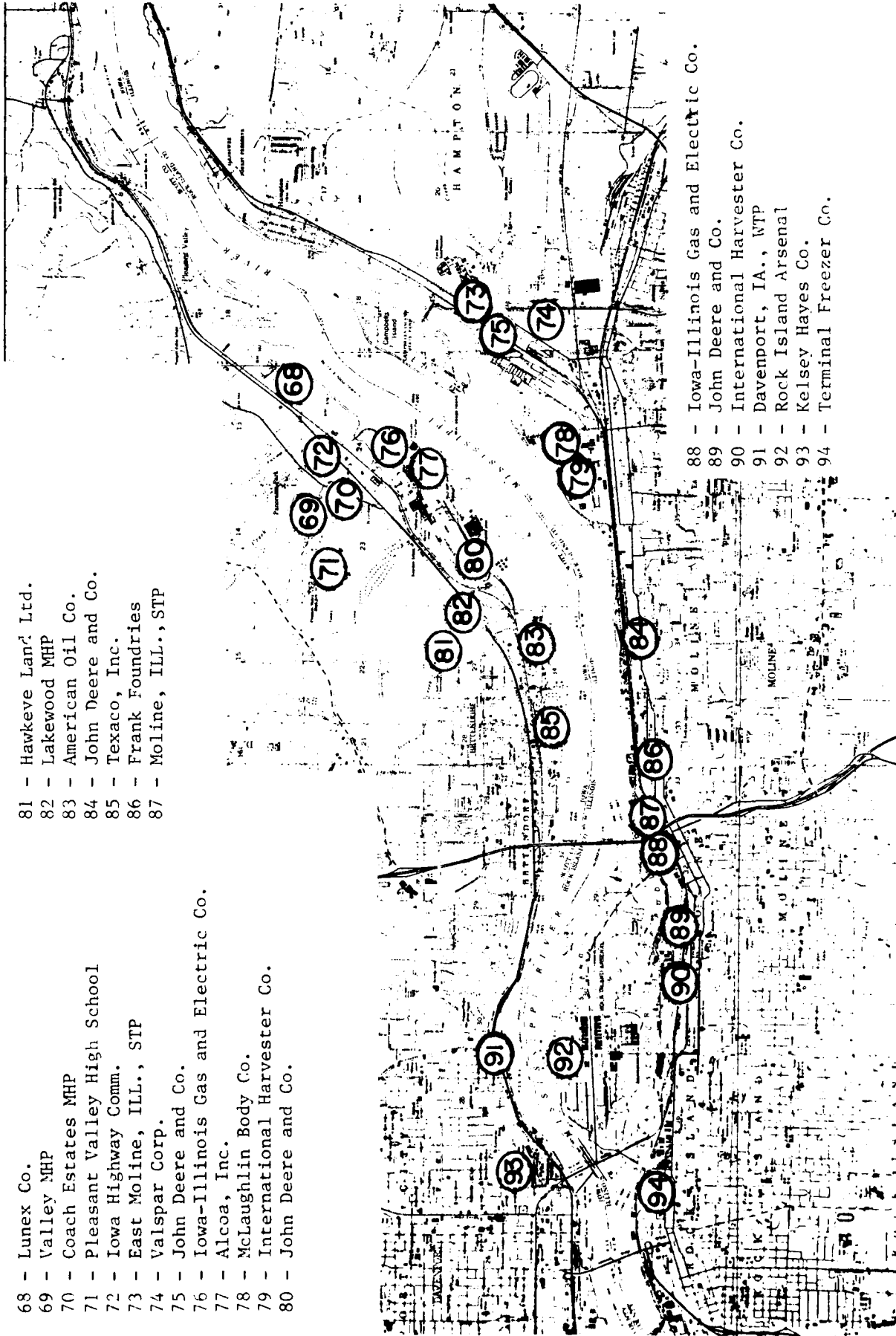
- 42 - Fulton, IA., STP
- 43 - Swift Dairy and Poultry Co.
- 44 - National Ice Products Co.
- 45 - Clinton Ice Processing Co.
- 46 - E.I. DuPont Co.
- 47 - Setness Products Co.
- 48 - Waukesha Motor Co.
- 49 - Continental Oil Co.
- 50 - Hawkeve Chemical Co.
- 51 - Chemplex Co.
- 52 - Interstate Power Co.
- 53 - International Paper Co.
- 54 - Callis Co.
- 55 - Chicago and Northwestern R.R.
- 56 - Clinton, IA., STP



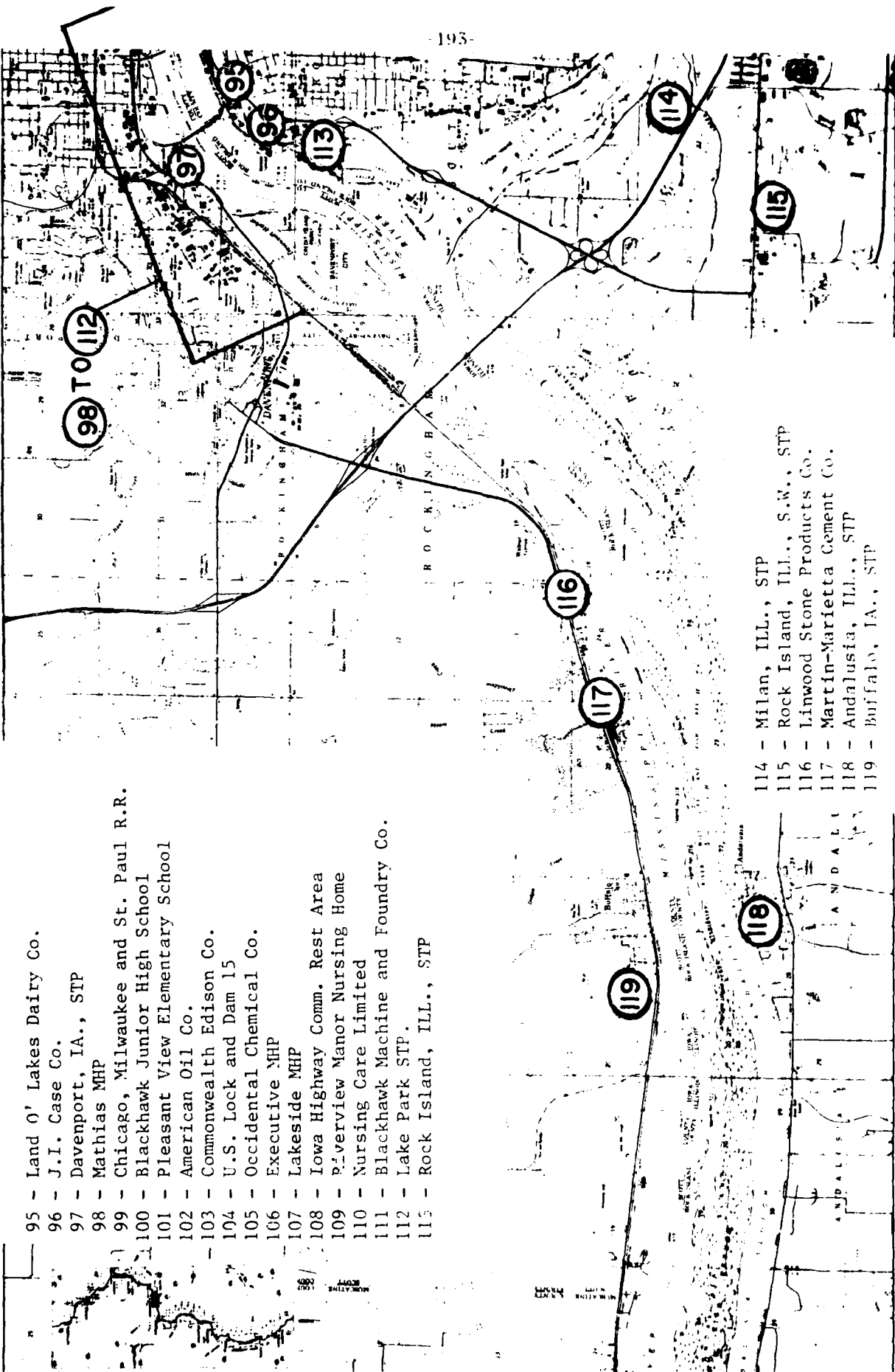
- 61 - Commonwealth Edison Co.  
(Quad City Nuclear Power Plant)
- 62 - Princeton, IA., STP
- 63 - Cordova, ILL., STP
- 64 - Port Byron, ILL., STP
- 65 - Le Claire Quarries Co.
- 66 - Le Claire, IA., STP
- 67 - Scenic Overlook



- 68 - Lunex Co.
- 69 - Valley MHP
- 70 - Coach Estates MHP
- 71 - Pleasant Valley High School
- 72 - Iowa Highway Comm.
- 73 - East Moline, ILL., STP
- 74 - Valspar Corp.
- 75 - John Deere and Co.
- 76 - Iowa-Illinois Gas and Electric Co.
- 77 - Alcoa, Inc.
- 78 - McLaughlin Body Co.
- 79 - International Harvester Co.
- 80 - John Deere and Co.
- 81 - Hawkeve Land Ltd.
- 82 - Lakewood MHP
- 83 - American Oil Co.
- 84 - John Deere and Co.
- 85 - Texaco, Inc.
- 86 - Frank Foundries
- 87 - Moline, ILL., STP



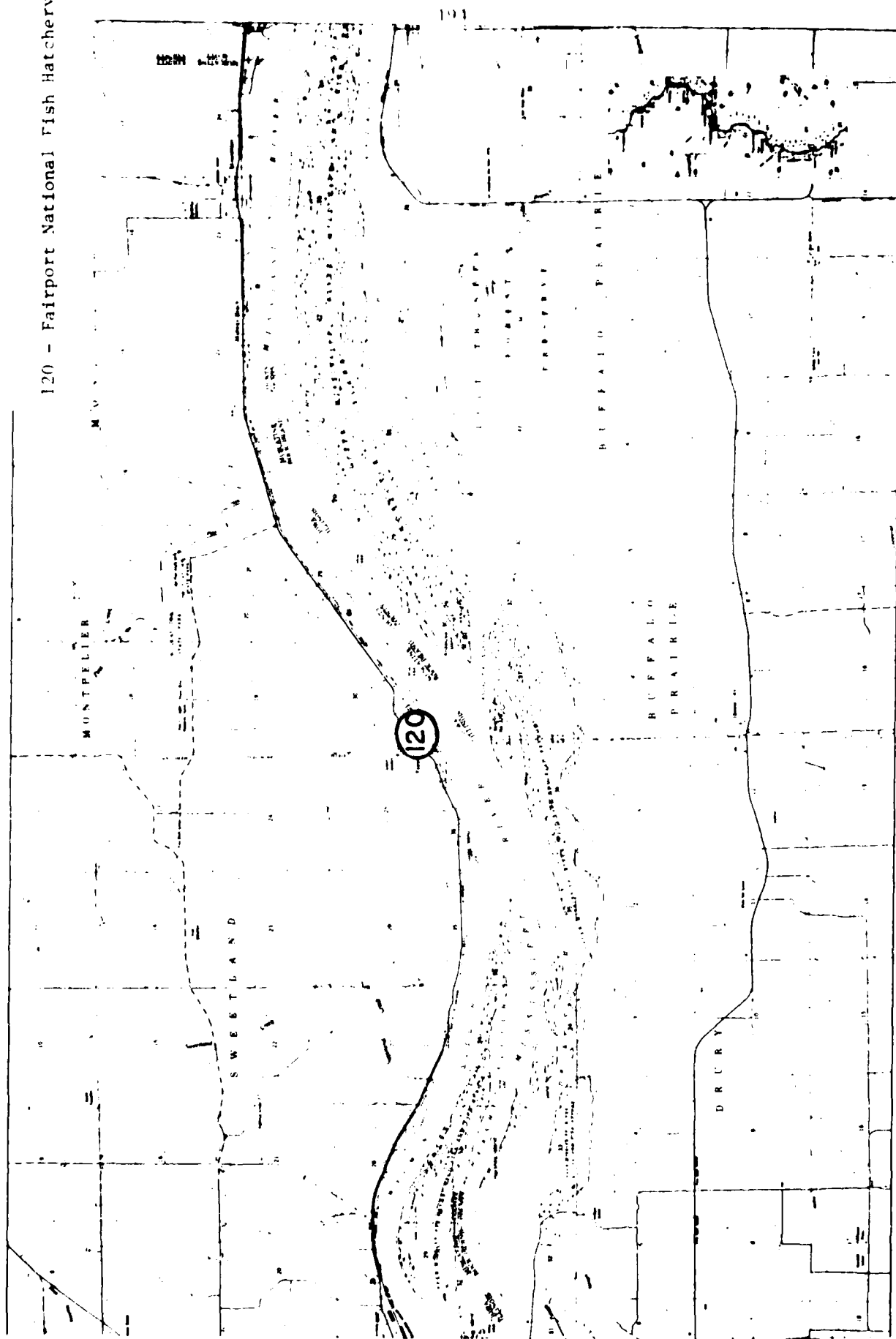
- 88 - Iowa-Illinois Gas and Electric Co.
- 89 - John Deere and Co.
- 90 - International Harvester Co.
- 91 - Davenport, IA., WTP
- 92 - Rock Island Arsenal
- 93 - Kelsey Hayes Co.
- 94 - Terminal Freezer Co.

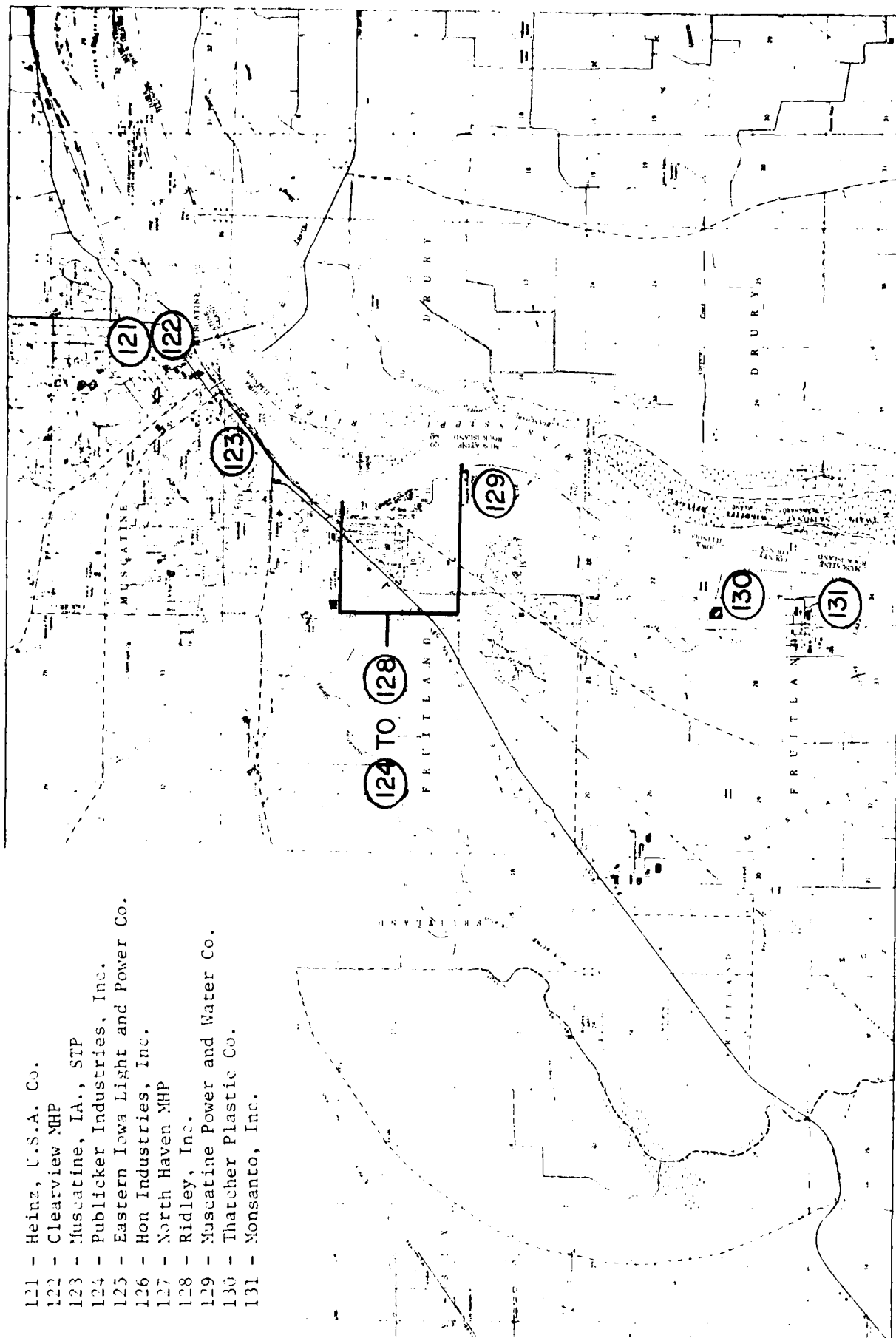


- 95 - Land O' Lakes Dairy Co.
- 96 - J.I. Case Co.
- 97 - Davenport, IA., STP
- 98 - Mathias MHP
- 99 - Chicago, Milwaukee and St. Paul R.R.
- 100 - Blackhawk Junior High School
- 101 - Pleasant View Elementary School
- 102 - American Oil Co.
- 103 - Commonwealth Edison Co.
- 104 - U.S. Lock and Dam 15
- 105 - Occidental Chemical Co.
- 106 - Executive MHP
- 107 - Lakeside MHP
- 108 - Iowa Highway Comm. Rest Area
- 109 - Piverview Manor Nursing Home
- 110 - Nursing Care Limited
- 111 - Blackhawk Machine and Foundry Co.
- 112 - Lake Park STP.
- 113 - Rock Island, ILL., STP

- 114 - Milan, ILL., STP
- 115 - Rock Island, ILL., S.W., STP
- 116 - Linwood Stone Products Co.
- 117 - Martin-Marietta Cement Co.
- 118 - Andalusia, ILL., STP
- 119 - Buffalo, IA., STP

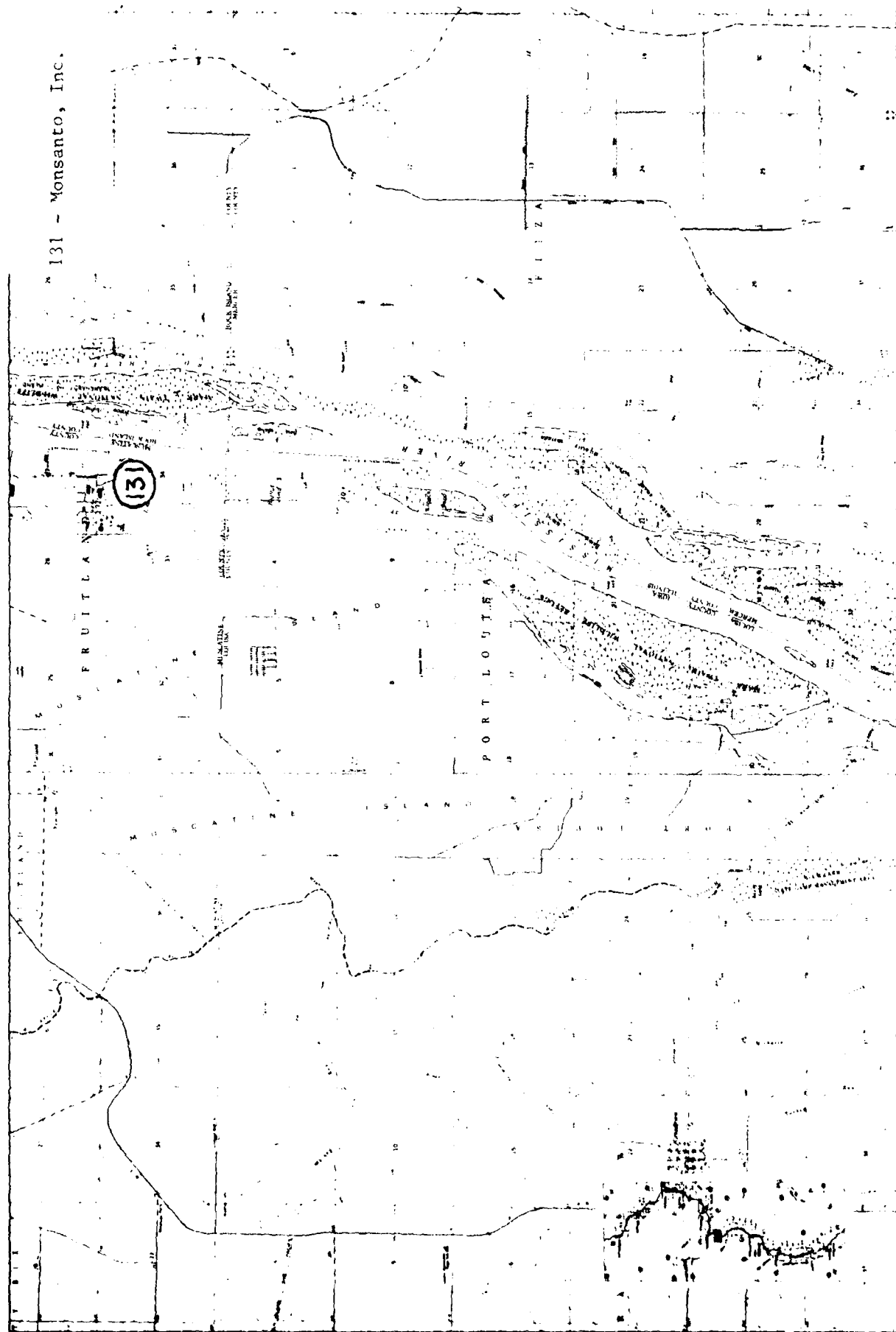
120 - Fairport National Fish Hatchery



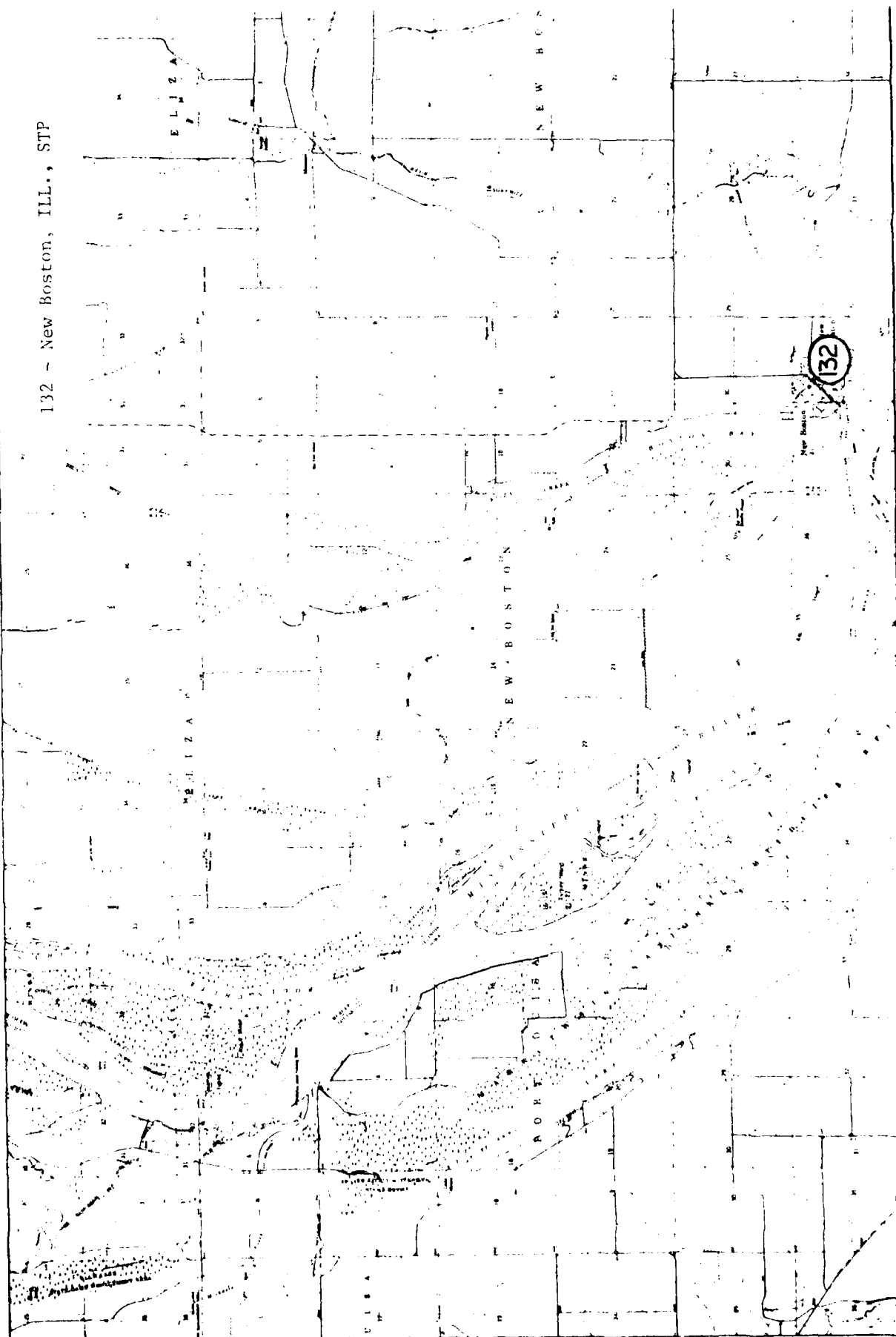


- 121 - Heinz, U.S.A. Co.
- 122 - Clearview MHP
- 123 - Muscatine, IA., STP
- 124 - Publicker Industries, Inc.
- 125 - Eastern Iowa Light and Power Co.
- 126 - Hon Industries, Inc.
- 127 - North Haven MHP
- 128 - Ridley, Inc.
- 129 - Muscatine Power and Water Co.
- 130 - Thatcher Plastic Co.
- 131 - Monsanto, Inc.

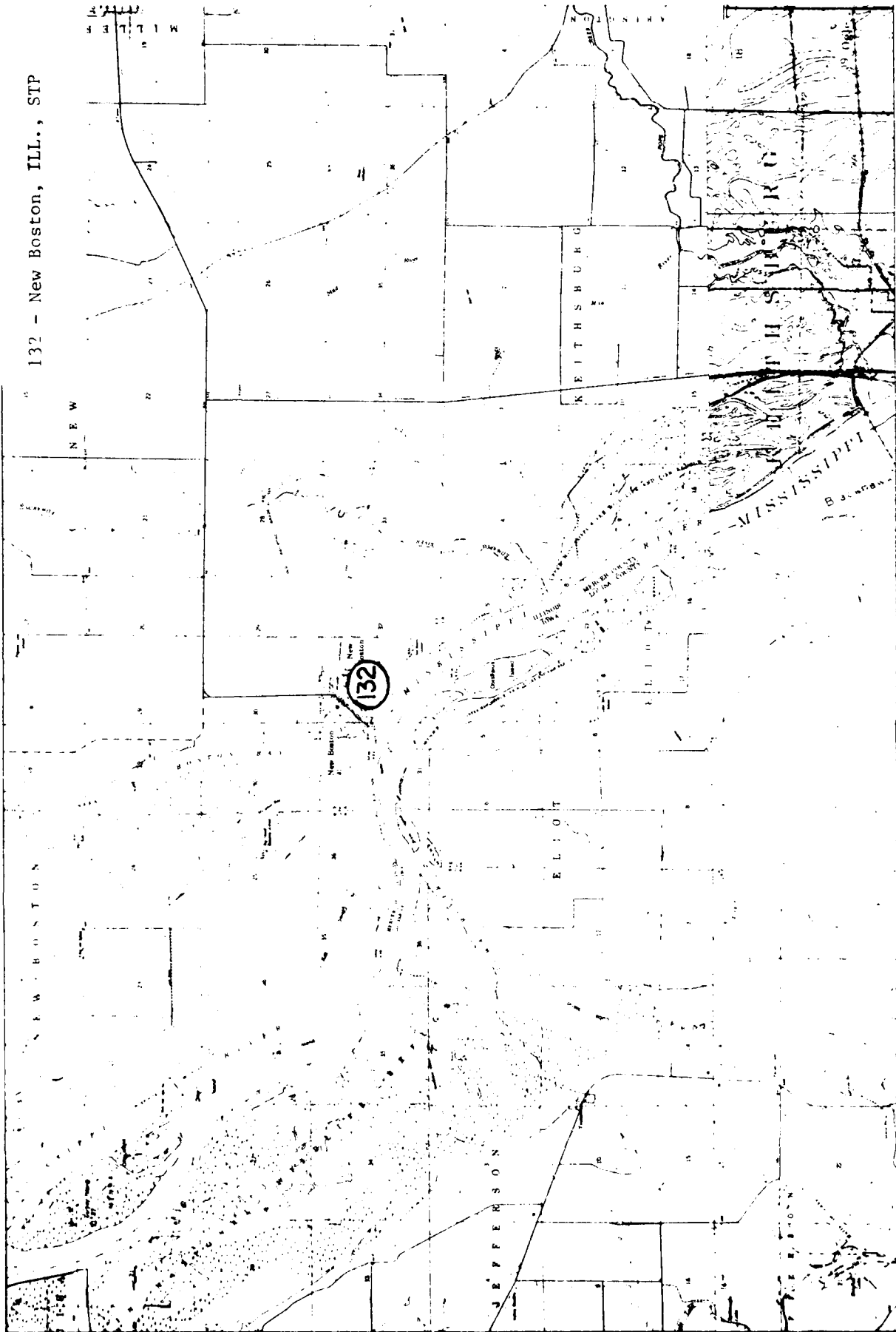
131 - Monsanto, Inc.



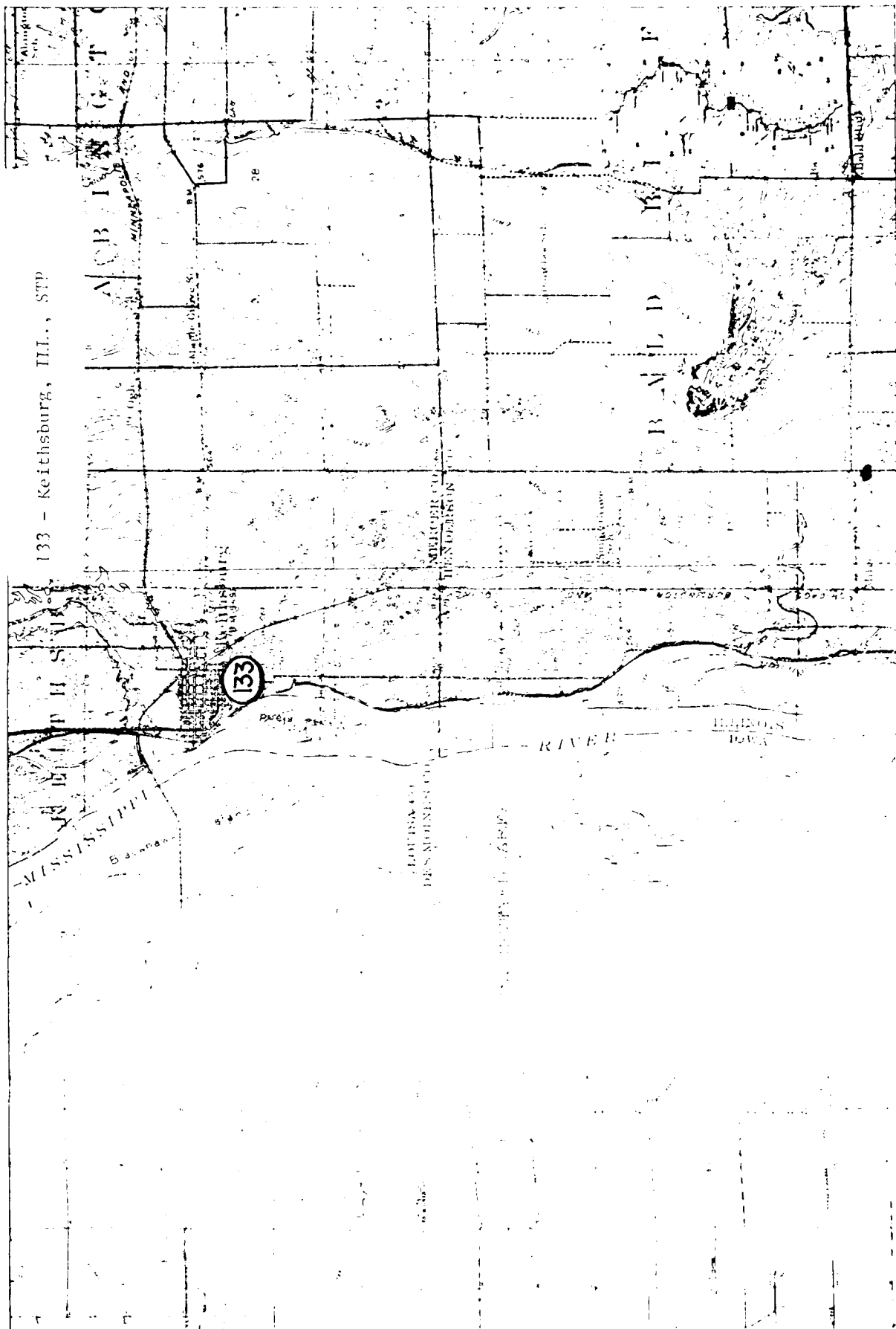
132 ~ New Boston, ILL., STP

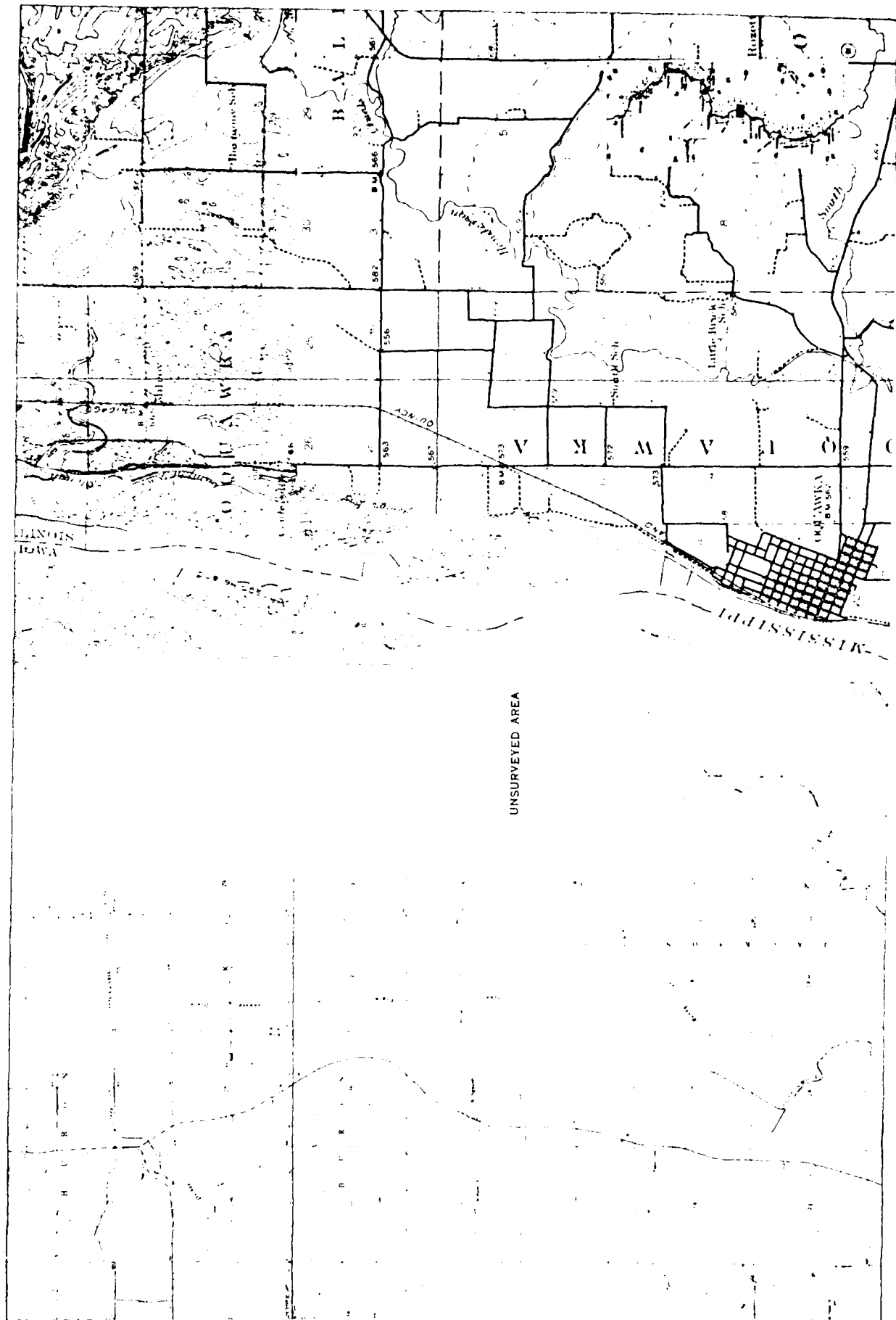


132 - New Boston, ILL., STP

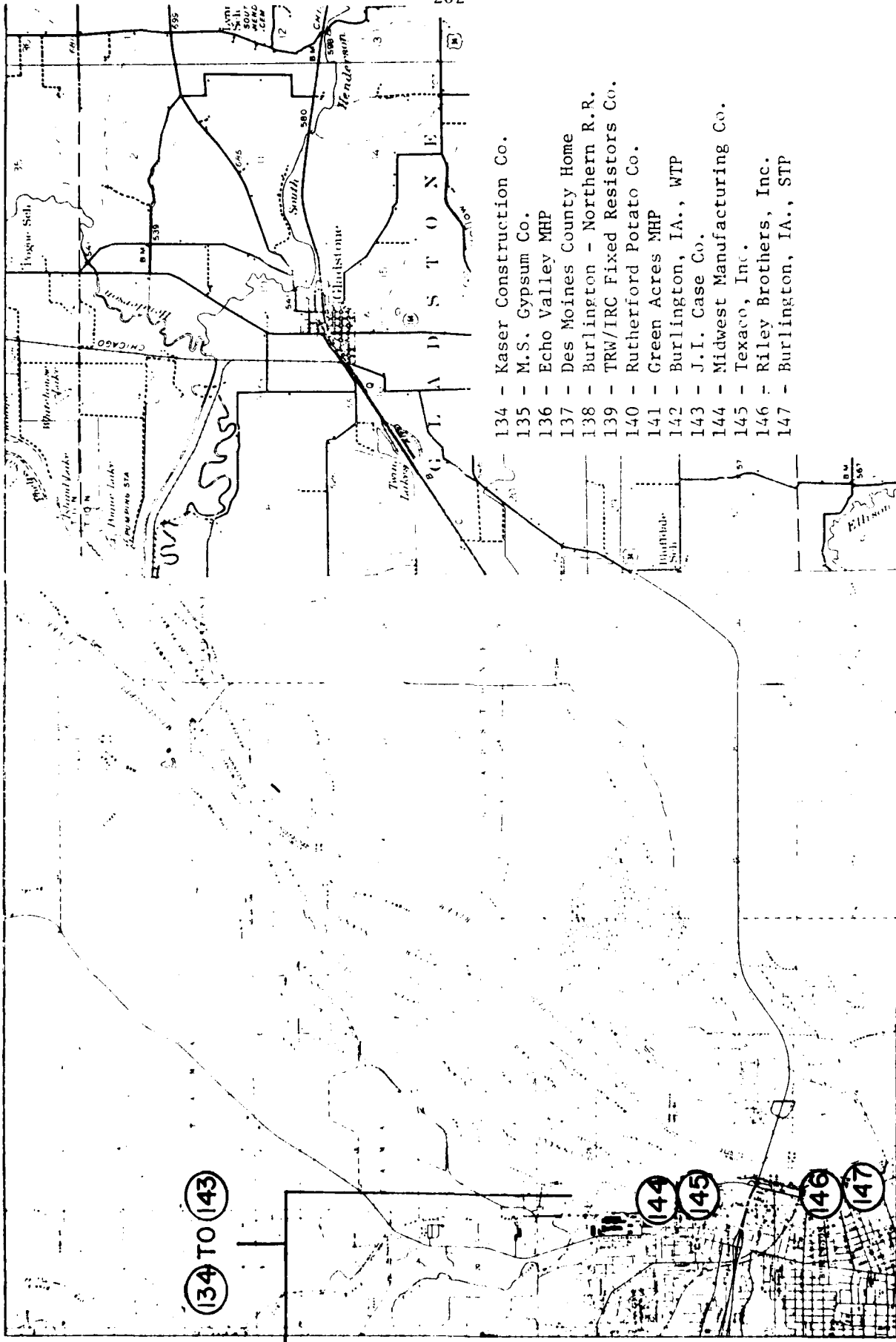


133 - Keithsburg, Ill., STP

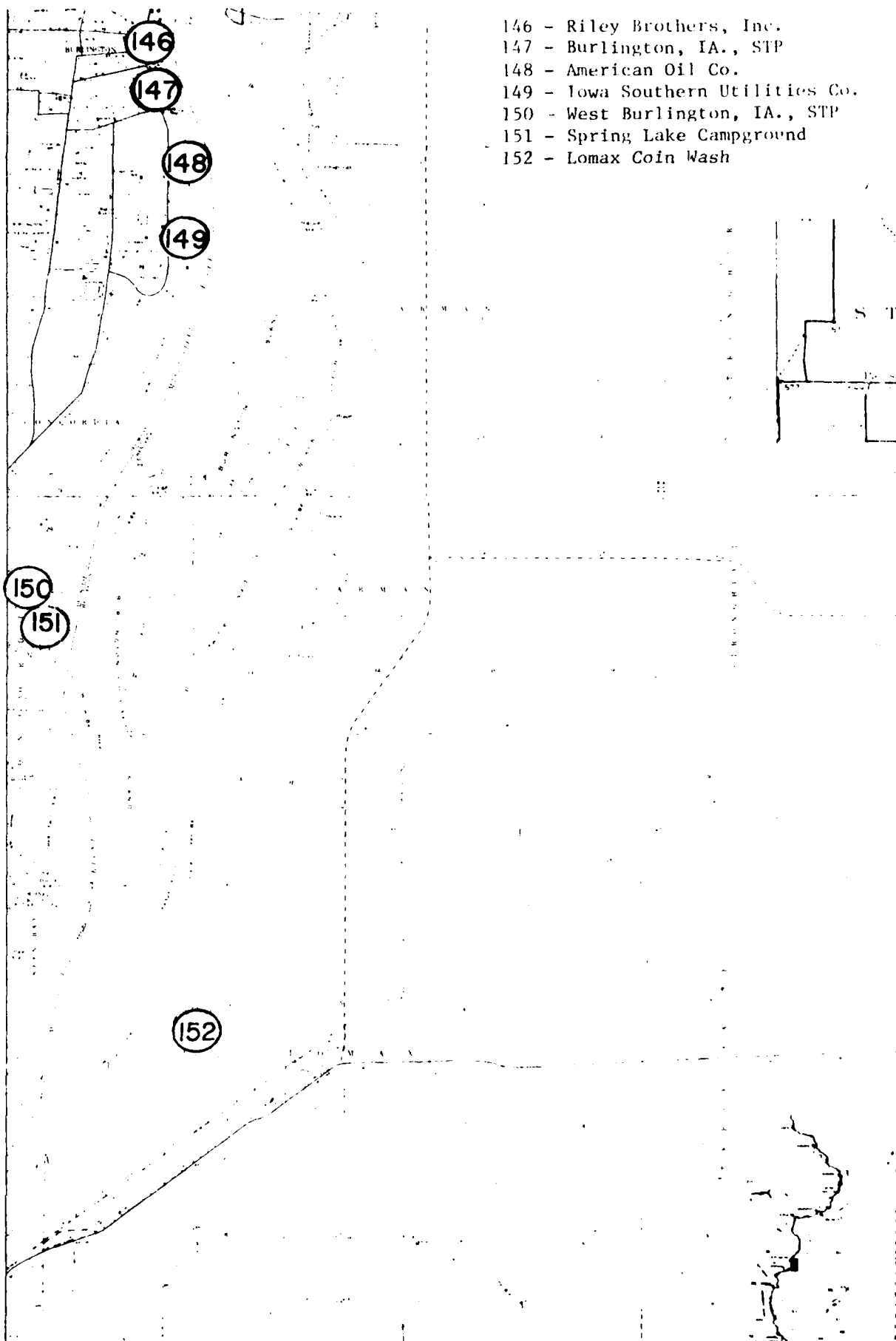


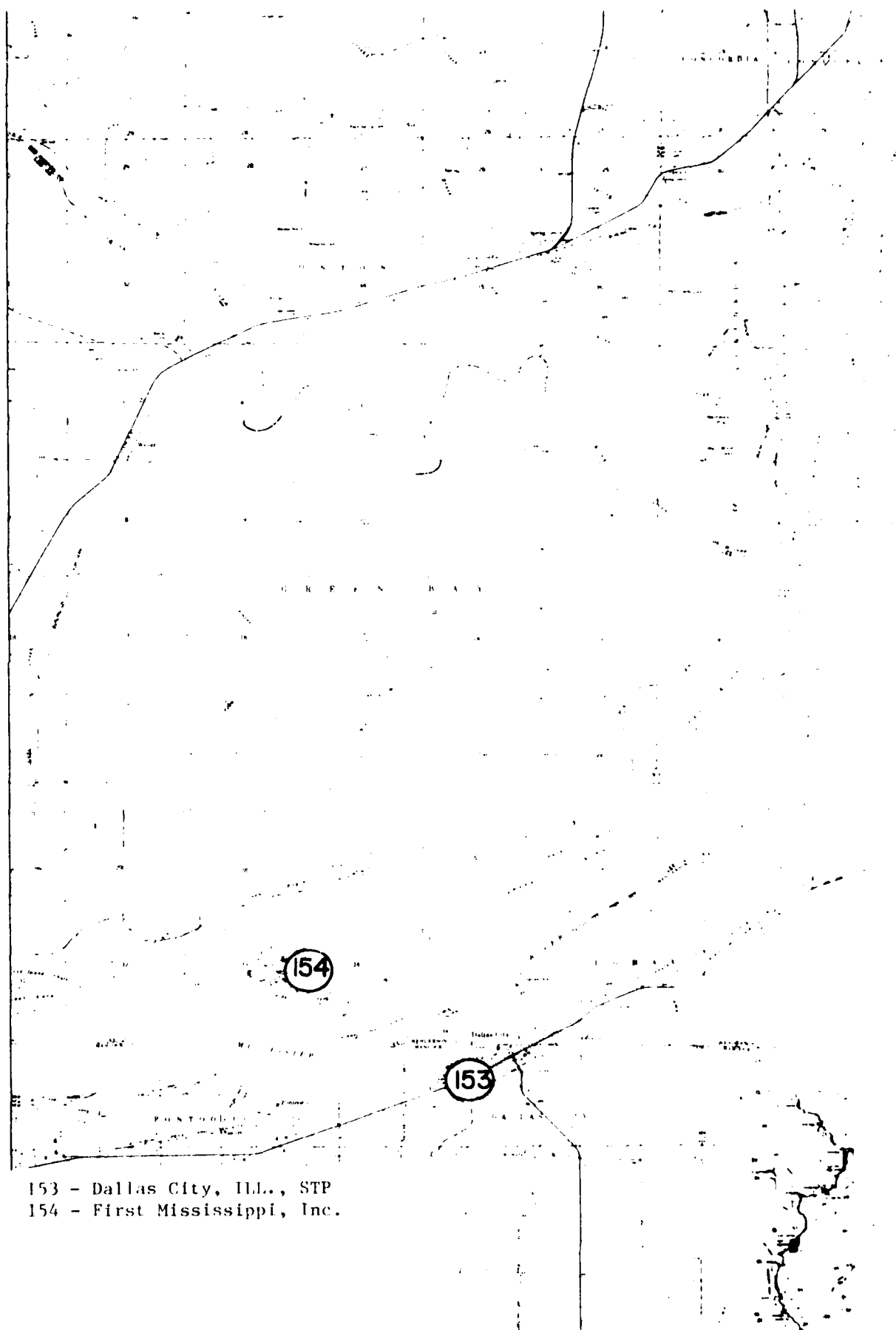






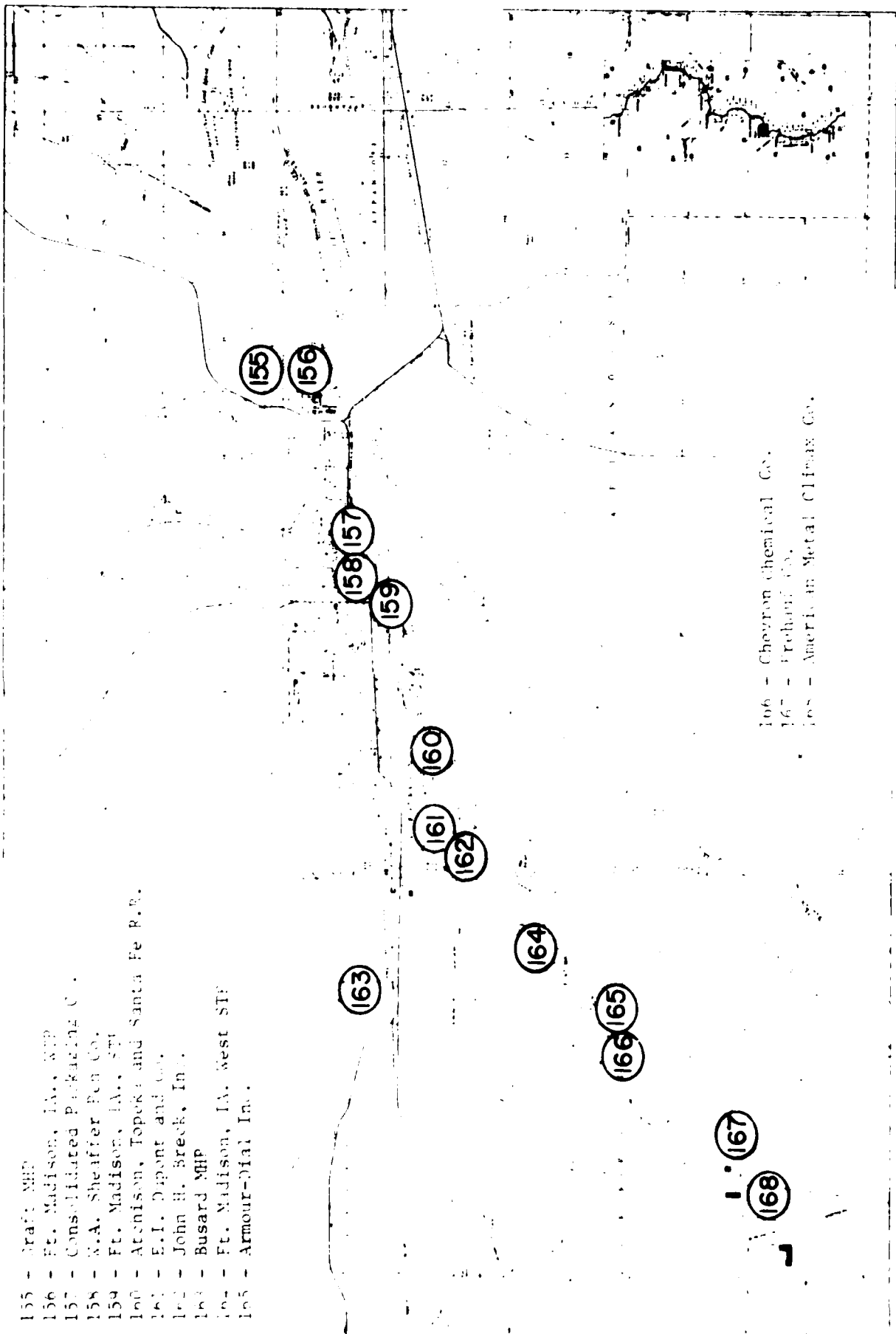
- 134 - Kaser Construction Co.
- 135 - M.S. Gypsum Co.
- 136 - Echo Valley MHP
- 137 - Des Moines County Home
- 138 - Burlington - Northern R.R.
- 139 - TRW/IRC Fixed Resistors Co.
- 140 - Rutherford Potato Co.
- 141 - Green Acres MHP
- 142 - Burlington, IA., WTP
- 143 - J.I. Case Co.
- 144 - Midwest Manufacturing Co.
- 145 - Texaco, Inc.
- 146 - Riley Brothers, Inc.
- 147 - Burlington, IA., STP



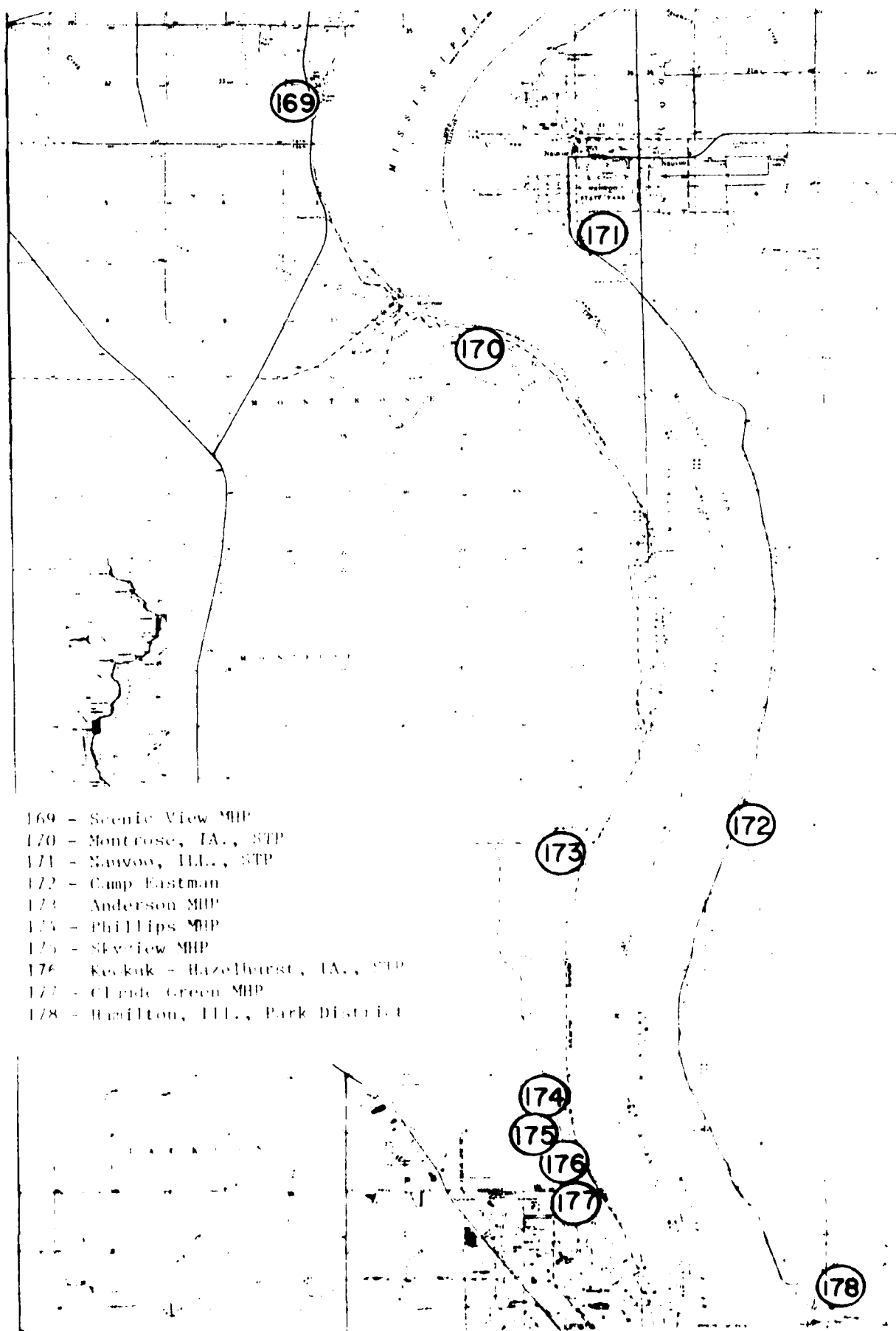


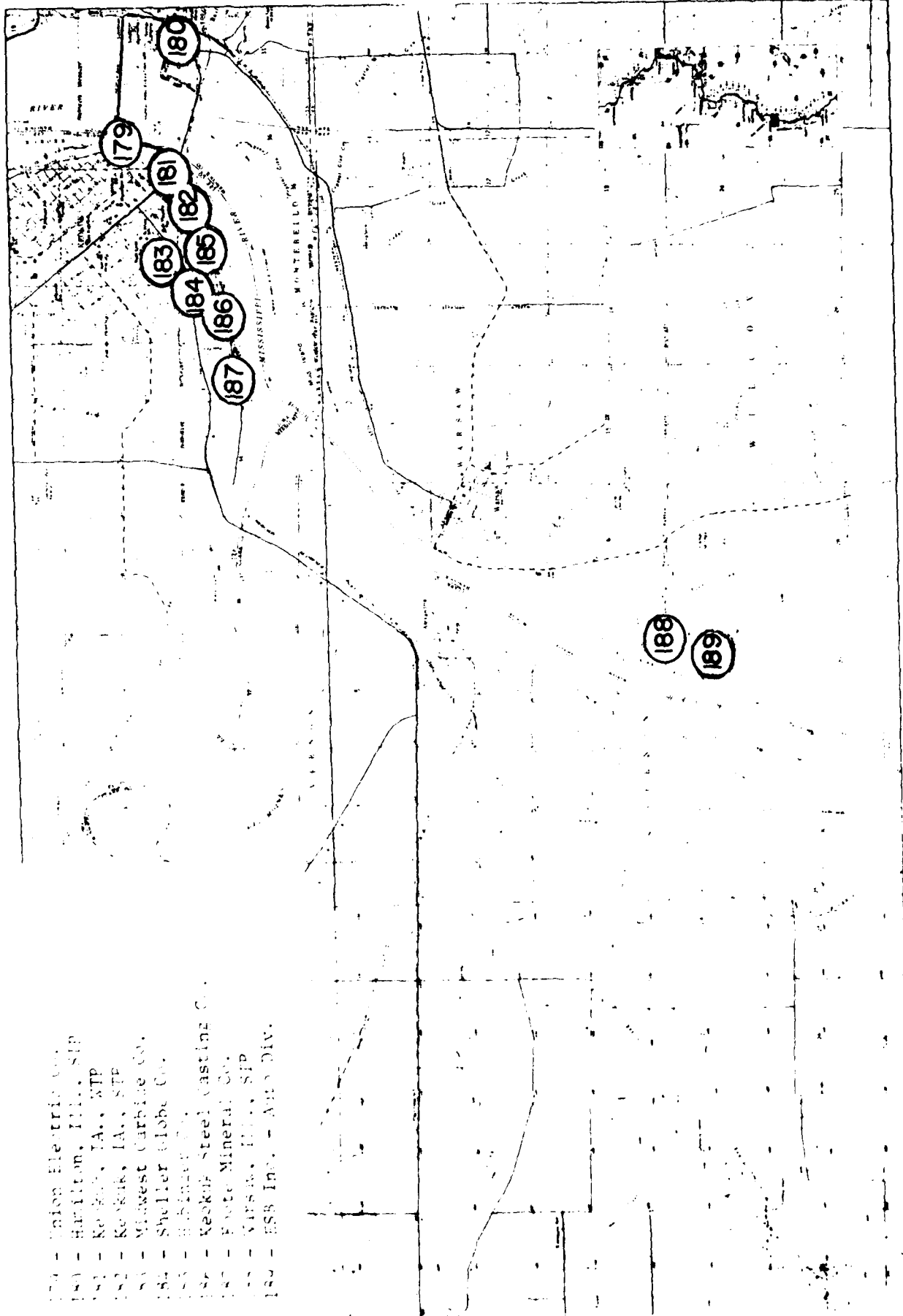
153 - Dallas City, Ill., STP  
154 - First Mississippi, Inc.

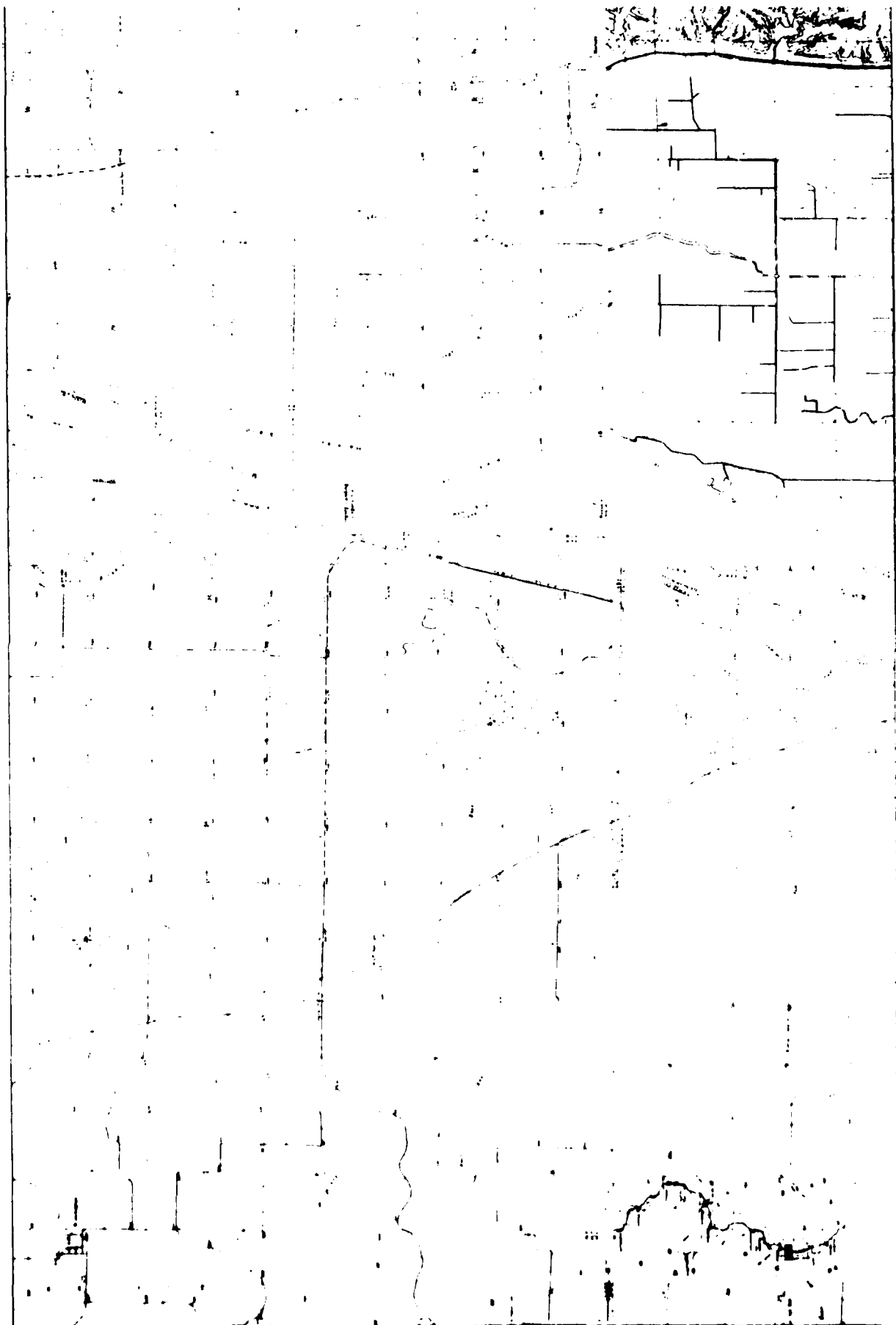
- 155 - Draft MHP
- 156 - Ft. Madison, IA., WTP
- 157 - Consolidated Packaging Co.
- 158 - W.A. Sheaffer Pen Co.
- 159 - Ft. Madison, IA., STP
- 160 - Atenison, Topeka and Santa Fe R.R.
- 161 - E.I. DuPont and Co.
- 162 - John H. Breck, Inc.
- 163 - Busard MHP
- 164 - Ft. Madison, IA. West STP
- 165 - Armour-Dial Inc.



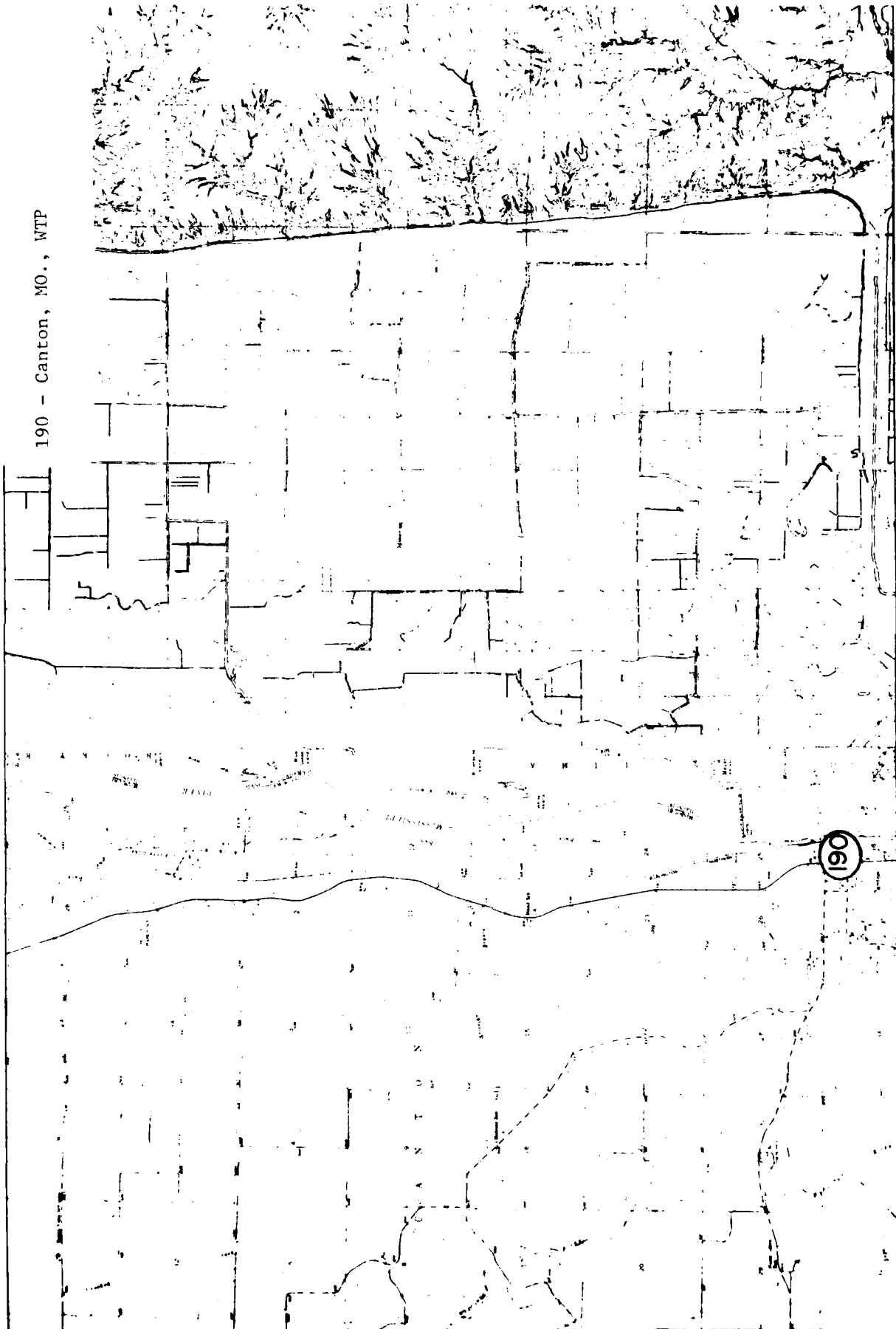
- 166 - Chevron Chemical Co.
- 167 - Frehauf Co.
- 168 - American Metal Climax Co.



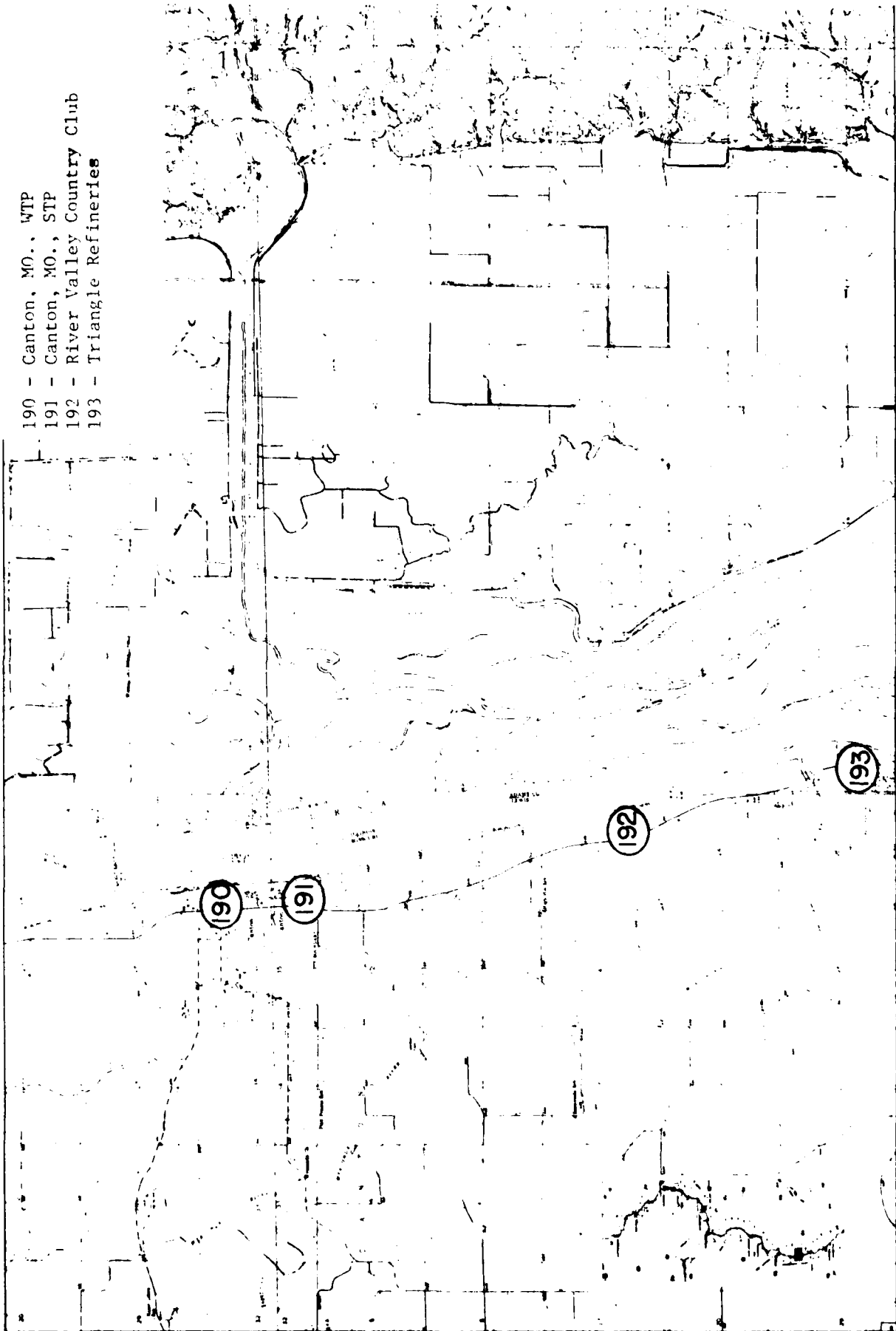




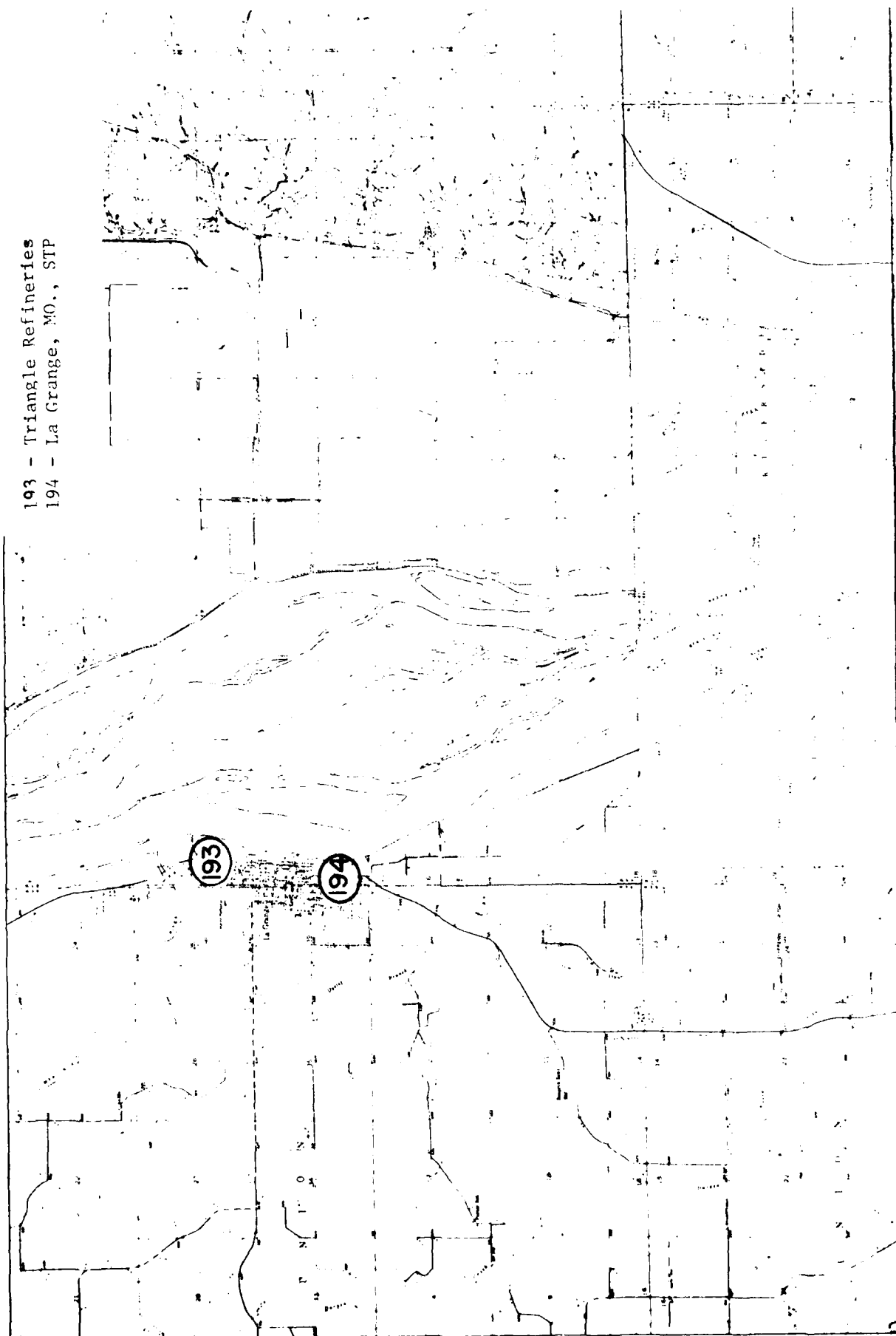
190 - Canton, MO., WTP



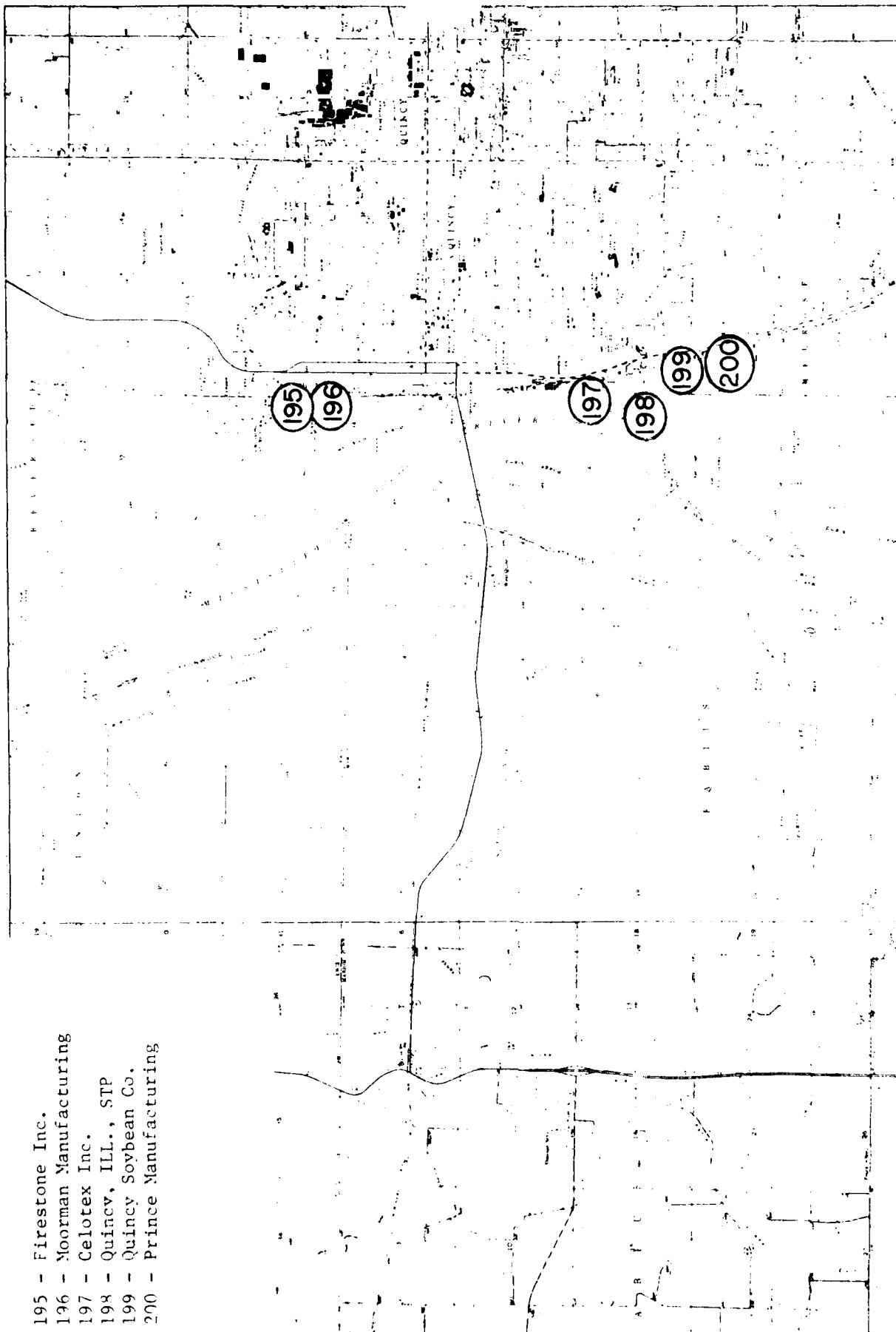
- 190 - Canton, MO., WTP
- 191 - Canton, MO., STP
- 192 - River Valley Country Club
- 193 - Triangle Refineries

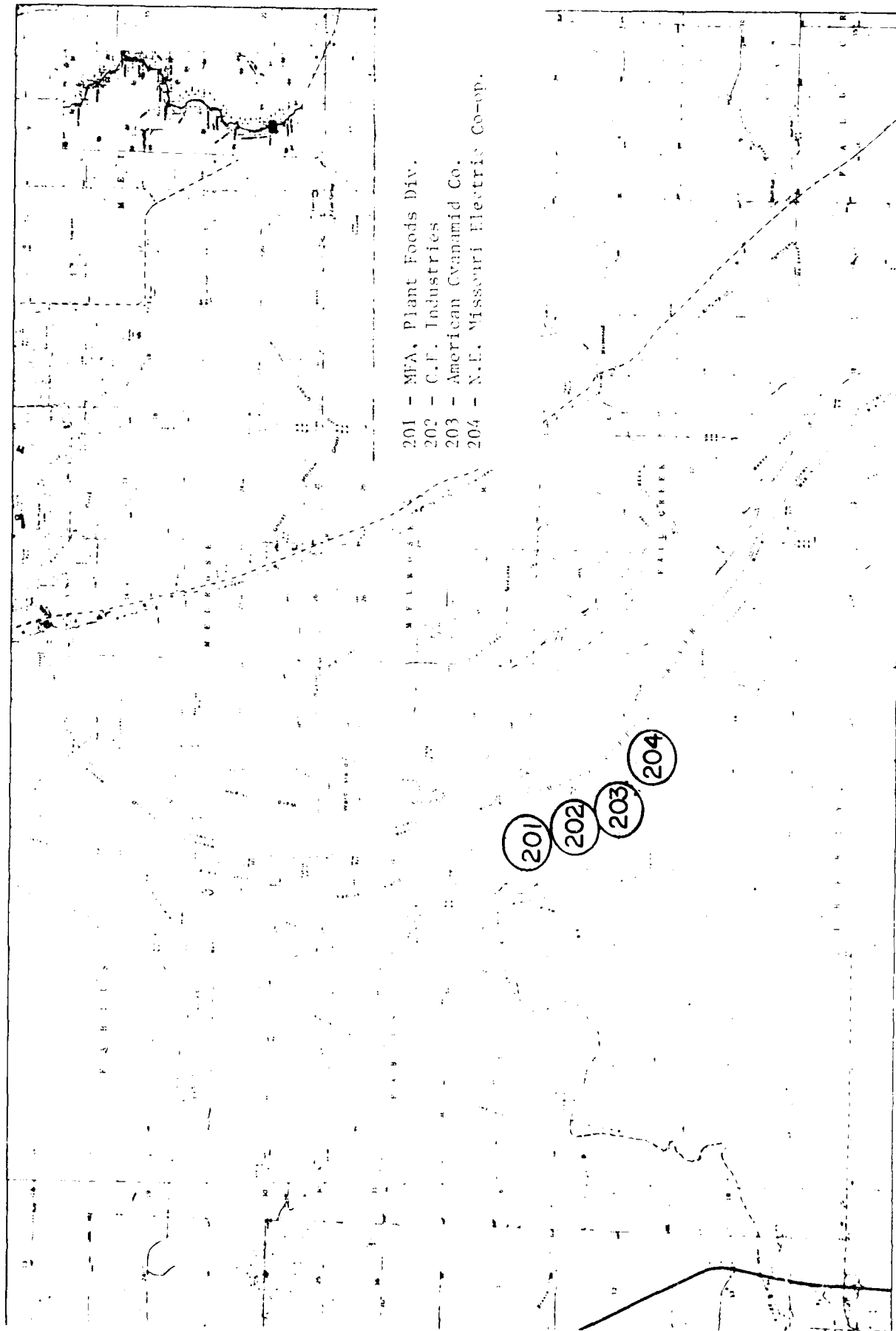


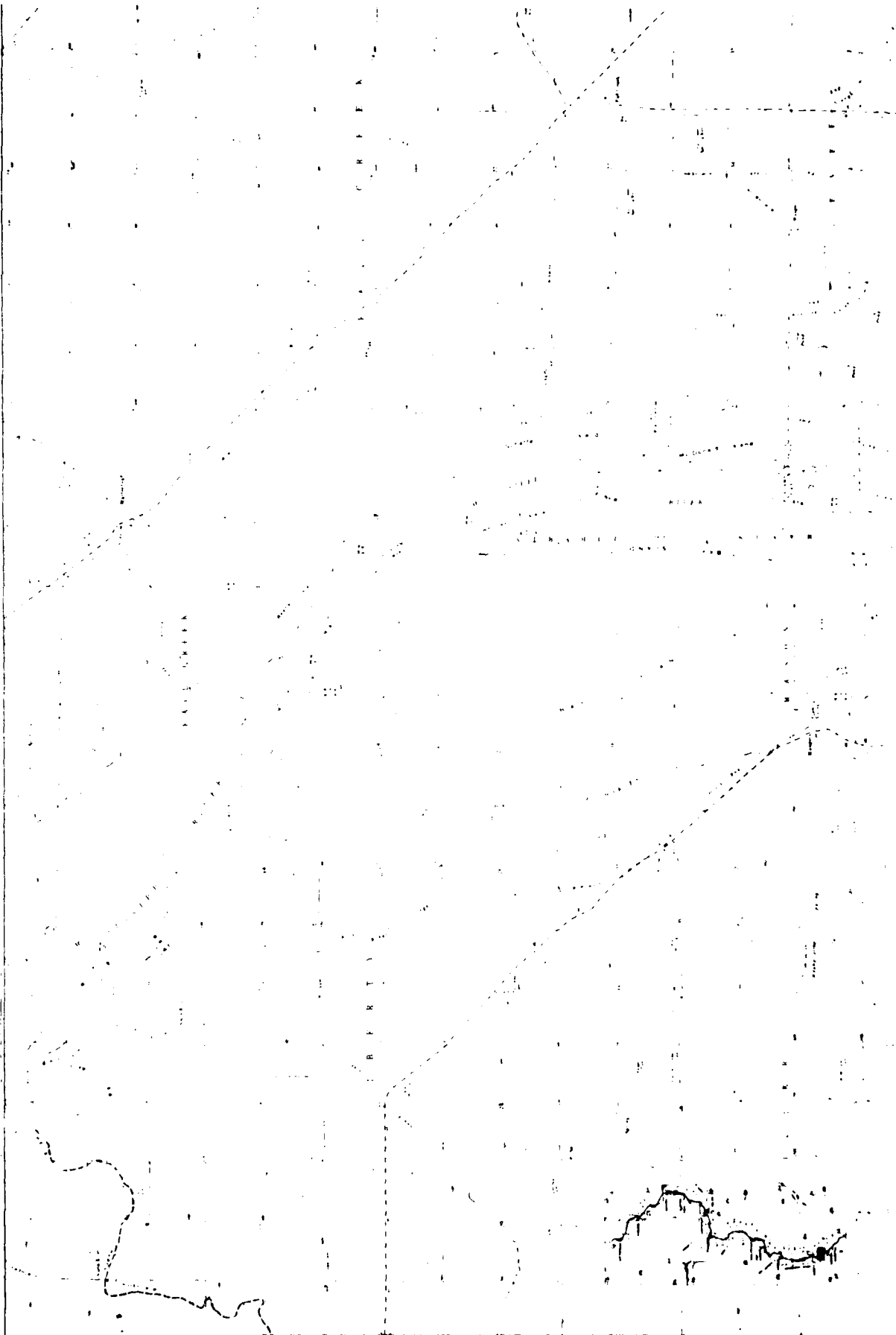
193 - Triangle Refineries  
194 - La Grange, MO., STP



- 195 - Firestone Inc.
- 196 - Moorman Manufacturing
- 197 - Celotex Inc.
- 198 - Quincy, ILL., STP
- 199 - Quincy Soybean Co.
- 200 - Prince Manufacturing







205 - Hannibal, MO., WTP  
206 - Hannibal, MO., STP  
207 - Burlington-Northern R.R. Yard

K I N D E R

